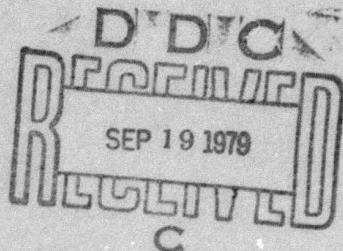


LEVEL 1
P2

AD A074014

SDAC-TR-78-9



PKP

TRAVEL TIMES AND B FACTORS

A.C. Chang & J.W. Lambert

Seismic Data Analysis Center

Teledyne Geotech, 314 Montgomery Street, Alexandria Virginia 22314

24 October 1978

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

DDC FILE COPY

Sponsored by

The Defense Advanced Research Projects Agency (DARPA)

ARPA Order No. 2551

Monitored By

AFTAC/VSC

312 Montgomery Street, Alexandria, Virginia 22314

79 09 19 323

Disclaimer: Neither the Defense Advanced Research Projects Agency nor the Air Force Technical Applications Center will be responsible for information contained herein which has been supplied by other organizations or contractors, and this document is subject to later revision as may be necessary. The views and conclusions presented are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency, the Air Force Technical Applications Center, or the US Government.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER SDAC-TR-78-9	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) PKP TRAVEL TIMES AND B FACTORS	5. TYPE OF REPORT & PERIOD COVERED Technical report	
6. AUTHOR(s) Andre C. Chang John W. Lambert	7. PERFORMING ORG. REPORT NUMBER F08606-79-C-0007 Rev	
8. CONTRACT OR GRANT NUMBER(s) ARPA Order - 2551	9. PERFORMING ORGANIZATION NAME AND ADDRESS Teledyne Geotech 314 Montgomery Street Alexandria, Virginia 22314	
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	11. CONTROLLING OFFICE NAME AND ADDRESS Defense Advanced Research Projects Agency Nuclear Monitoring Research Office 1400 Wilson Blvd., Arlington, Virginia 22209	
12. REPORT DATE 24 October 1978	13. NUMBER OF PAGES 53	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) VELA Seismological Center 312 Montgomery Street Alexandria, Virginia 22314	15. SECURITY CLASS (of this report) Unclassified	
16. DISTRIBUTION STATEMENT (of this Report) APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.	17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) LPN AFTAC-VT-	
18. SUPPLEMENTARY NOTES Author's Report Date 06/30/78		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) PKP Travel Times PKP Amplitudes B Factors for PKP Time/Amplitude for PKP		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Using Jordan and Anderson's earth model B1, we calculated theoretical travel times, depth allowance tables, branch interval times, and B factors for all PKP phases; the results are in tabular form. Travel times are calculated with polynomial approximations, and those coefficients are also computed.		
New additions to those tables are the data for the CD branch, which are the PKiKP arrivals in the distance range of 109° to 158°. Although travel times of the CD branch fall within a few seconds of the travel times of the		

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

408 258

deg

103 page

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

DF branch, amplitudes of the CD branch signals are larger than those of the DF branch signals in most of the covering range.

Discrepancies of theoretical travel times from the table based on Bolt's observations are calculated to show that tables presented here are adequate for practical use.

Attachment For

NTIS G-1&I
DDG TAB

Unannounced

Justification _____

By _____

Distribution/

Availability Codes

Dist	Avail and/or special
A	

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

PKP TRAVEL TIMES AND B FACTORS

SEISMIC DATA ANALYSIS CENTER REPORT NO.: SDAC-TR-78-9

AFTAC Project Authorization No.: VELA T/9709/B/ETR
Project Title: Seismic Data Analysis Center
ARPA Order No.: 2551

Name of Contractor: TELEDYNE GEOTECH

Contract No.: F08606-79-C-0007
Date of Contract: 01 October 1978
Amount of Contract: \$377,990
Contract Expiration Date: 30 September 1979
Project Manager: Robert R. Blandford
(703) 836-3882

P. O. Box 334, Alexandria, Virginia 22313

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

ABSTRACT

Using Jordan and Anderson's earth model B1, we calculated theoretical travel times, depth allowance tables, branch interval times, and B factors for all PKP phases; the results are in tabular form. Travel times are calculated with polynomial approximations, and those coefficients are also computed.

New additions to those tables are the data for the CD branch, which are the PKiKP arrivals in the distance range of 109° to 158° . Although travel times of the CD branch fall within a few seconds of the travel times of the DF branch, amplitudes of the CD branch signals are larger than those of the DF branch signals in most of the covering range.

Discrepancies of theoretical travel times from the table based on Bolt's observations are calculated to show that tables presented here are adequate for practical use.

TABLE OF CONTENTS

	Page
ABSTRACT	3
LIST OF FIGURES	5
LIST OF TABLES	6
INTRODUCTION	7
COMPUTATION OF TRAVEL TIMES	9
POLYNOMIAL APPROXIMATION OF PKP TRAVEL TIMES	30
B FACTORS FOR PKP	37
CONCLUSIONS	51
ACKNOWLEDGEMENTS	52
REFERENCES	53

LIST OF FIGURES

Figure No.	Title	Page
1	Comparison of theoretical PKP travel times with Bolt's PKP table.	29
2	Travel time errors of PKP-AB branch computed with polynomial approximation. Numbers indicate depth of epicenter in hundreds of kilometers.	32
3	Travel time errors of PKP-BC branch computed with polynomial approximation. Numbers indicate depth of epicenter in hundreds of kilometers.	33
4	Travel time errors of PKP-CD branch computed with polynomial approximation. Numbers indicate depth of epicenter in hundreds of kilometers.	34
5	Travel time errors of PKP-DF branch computed with polynomial approximation. Numbers indicate depth of epicenter in hundreds of kilometers.	35
6	Comparison of PKP travel times computed with polynomial approximation against Bolt's PKP table.	36
7	The Q model of the earth used in PKP amplitude computation as compared with Veith and Clawson's Mantle Q and Doornbos' core Q model.	39
8	PKP travel times and amplitudes computed for model B1.	40
9	B factors for PKP-AB branch.	41
10	B factors for PKP-BC branch.	42
11	B factors for PKP-CD branch.	43
12	B factors for PKP-DF branch. Sweetser's and Blandford's practical B-factor for PKP are plotted in dotted line for comparison.	44

LIST OF TABLES

Table No.	Title	Page
I	Travel times of PKP AB, BC, CD, and DF branches.	10
II	Depth allowance tables for PKP AB, BC, CD, and DF branches.	16
III	Travel time differences of PKP AB, BC, CD, and DF branches.	20
IV	Coefficients for PKP travel times with polynomial approximation $T = A_1 + A_2\Delta + A_3h + A_4\Delta^2 + A_5\Delta h + A_6h^2 + A_7\Delta^3.$	31
V	B-factor tables for PKP AB, BC, CD, and DF branches.	45

INTRODUCTION

This report presents a complete set of theoretical PKP data in convenient tables, including tables of travel times of each branch at one degree intervals and at nine different source depths. Also calculated are depth allowance tables, branch interval times at various depths, and B factors for various depths.

While such tables are essential tools for data analysts and for computer programs analyzing PKP phases, only a few tables have been published. Therefore, many workers have been forced to rely upon Jeffreys' and Bullen's (J-B) seismological tables (1958), which do not give PKP travel times in convenient one-degree intervals. Later, Travis (1965) published a complete set of interpolated J-B tables for 40 different phases, both for practical use and to avoid numerous repetitive interpolations. However, the PKP travel times in the J-B tables are, according to workers, in error by approximately two seconds. Recent PKP tables, such as Hai's (1963) or Engdahl's (1968), derived from observational explosion data, are not listed at one degree intervals and they are for only one depth. Bolt (1968) published another, more widely used, table of PKP travel times at one degree intervals. This table is for surface focus and incorporates a depth allowance table to compensate for the source depth factor. However, more recent studies have indicated that the GH branch in the Bolt's table is suspicious (for example, see, Engdahl, 1968; Cleary and Haddon, 1972).

Jeffreys, H. and Bullen, K. E., 1958, Seismological Tables: British Association for the Advancement of Science Publication.

Travis, H. S., 1965, Interpolated Jeffreys and Bullen Seismological Tables, Geotech, TR-65-35, Garland, Texas.

Hai, N., 1963, Propagation des Ondes Longitudinales dans le Noyau Terrestre; Ann. Geophys., 19, 285-346.

Engdahl, E. R., 1968, Core Phases and the Earth's Core, Ph.D. Thesis, St. Louis University.

Bolt, B. A., 1968, Estimation of PKP Travel Times; Bull. Seism. Soc. Am., 58, 1305-1324.

Cleary, J. R. and R. A. W. Haddon, 1972, Seismic wave scattering near the core-mantle boundary: a new interpretation of precursors to PKP; Nature, 240, 549-551.

To fill this void a new set of PKP tables without these shortcomings is needed. We have adopted Jordan and Anderson's Earth model B1 (1974) and computed theoretical travel times and amplitudes. However, the accuracy of these values depends upon the model, a subject beyond the scope of this report. While some workers may argue that a better model exists, this model remains a widely accepted 'typical' earth model (for example, Jacobs, 1975) and travel times of PnKP phases agree with our observations at the Seismic Data Analysis Center (SDAC). A new contribution of this report is the addition of the receding CD branch, or the PKiKP phase, in the range of 109° to 158° . Although many previous studies have neglected this phase, experience shows that the signal is nonetheless commonly observable in this range. However, while this fact has been cited by Bolt (1968), Hai (1963), and Engdahl (1968), none included this branch in their tables.

Jordan, T. H., and D. L. Anderson, 1974, Earth structure from free oscillations and travel times; Geophys. J. R. Astr. Soc., 36, 411-459.

Jacobs, J. A., 1975, The Earth's Core: New York, Academic Press.

COMPUTATION OF TRAVEL TIMES

We computed theoretical travel times with Engdahl's (1968) program, CORE, and with Jordan and Anderson's model B1, (1974). CORE was modified to compute the receding CD branch in the range of 109° to 158° . These travel times are tabulated in Table I. In Table II, depth allowances, i.e., the travel time differences of PKP surface events and PKP depth events, are tabulated. This table is useful in estimating event depth when a discrepancy is found between the expected arrival time and the actual arrival time. In Table III branch interval times, or the difference in travel times between two PKP phases, are shown in various combinations and depths. This table can be used to determine or to adjust the epicenter to station distance when two PKP phases are identified in the record.

To evaluate the travel times, those computed with model B1 were compared to Bolt's PKP travel times, which were based upon observed data. However, because Bolt's tables do not have a BC branch, we compared the GH branch of the Bolt's table with the BC branch of the model B1; Figure 1 details the result. When comparing B1 to other models, we have shown the travel time difference of Bolt's travel times with the theoretical travel times computed with Herrin's (1968) mantle and Qamar's core model KOR5 (1973). The dotted lines in Figure 1 show this model's travel time difference. In this comparison, both models agree within one second with Bolt's travel times for the AB and DF branches. Although the KOR5 times seem closer to Bolt's values, there are several discrepancies: 1) Qamar's DF branch terminates at 120° while Bolt's value extends to 109° ; and 2) the GH branch terminates at 141° whereas Bolt's GH branch extends to 125° . In general, model B1 is adequate for modern use, because an error of one second is within the bounds of observational uncertainties.

Herrin, E., 1968, P-Wave Velocity Distribution in the Mantle; Bull. Seism. Soc. Am., 58, 1223-1225.

Qamar, A., 1973, Revised Velocities in the Earth's Core; Bull. Seism. Soc. Am., 63, 1073-1106.

TABLE I
TRAVEL TIMES OF PKP-AB BRANCH
(JORDAN AND ANDERSON MODEL 91)

TABLE I (Continued)

TRAVEL TIMES OF PKP-BC BRANCH
(JORDAN AND ANDERSON MODEL B1)

	100	200	300	400	500	600	700	800
	MIN SEC							
0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
143	0-024	0-046	0-071	0-102	0-133	0-164	0-195	0-226
144	1-940	1-946	1-951	1-956	1-961	1-966	1-971	1-976
145	1-943	1-949	1-954	1-959	1-964	1-969	1-974	1-979
146	1-943	1-949	1-954	1-959	1-964	1-969	1-974	1-979
147	1-948	1-954	1-959	1-964	1-969	1-974	1-979	1-984
148	1-948	1-954	1-959	1-964	1-969	1-974	1-979	1-984
149	1-948	1-954	1-959	1-964	1-969	1-974	1-979	1-984
150	1-950	1-956	1-961	1-966	1-971	1-976	1-981	1-986
151	1-952	1-958	1-963	1-968	1-973	1-978	1-983	1-988
152	1-953	1-959	1-964	1-969	1-974	1-979	1-984	1-989
153	1-954	1-960	1-965	1-970	1-975	1-980	1-985	1-990
154	1-954	1-960	1-965	1-970	1-975	1-980	1-985	1-990
155	1-955	1-961	1-966	1-971	1-976	1-981	1-986	1-991
156	1-956	1-962	1-967	1-972	1-977	1-982	1-987	1-992
157	1-957	1-963	1-968	1-973	1-978	1-983	1-988	1-993
158	1-958	1-964	1-969	1-974	1-979	1-984	1-989	1-994

TABLE I (Continued)

TRAVEL TIMES OF PKP-CD BRANCH
(JORDAN AND ANDERSON MODEL B1)

TABLE I (Continued)

TRAVEL TIMES OF PKP-CD BRANCH
(JORDAN AND ANDERSON MODEL R1)

0	100			200			300			400			500			600			700			800		
	MN	SEC	MN	SEC	MN	SEC	MN	SEC	MN	SEC	MN	SEC	MN	SEC	MN	SEC	MN	SEC	MN	SEC	MN	SEC	MN	SEC
153	20	0.49	19	47.36	19	35.32	19	23.59	19	12.16	19	1.65	18	51.61	18	42.07	18	33.25	18	35.34	18	37.43	18	39.53
154	20	2.58	19	49.45	19	37.40	19	25.68	19	14.25	19	3.74	18	53.70	18	44.16	18	46.25	18	48.34	18	50.43	18	52.62
155	20	4.67	19	51.54	19	39.50	19	27.77	19	16.34	19	5.83	18	55.79	18	48.88	18	51.97	18	54.06	18	57.15	18	59.24
156	20	6.77	19	53.63	19	41.59	19	29.86	19	18.43	19	7.92	18	57.88	18	50.97	18	53.06	18	56.15	18	59.24	18	62.33
157	20	8.86	19	55.72	19	43.68	19	31.95	19	20.52	19	10.01	18	59.97	18	50.43	18	41.62	18	44.79	18	47.98	18	51.17
158	20	10.95	19	57.82	19	45.77	19	34.04	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

TABLE I (Continued)

TRAVEL TIMES OF PKP-DF BRANCH
(JORDAN AND ANDERSON MODEL B1)

TABLE I (Continued)

TRAVEL TIMES OF PKP-DF BRANCH
(JORDAN AND ANDERSON MODEL #1)

0	100	200	300	400	500	600	700	800
SEC	MIN SEC	MIN SEC	MIN SEC	MIN SEC	MIN SEC	MIN SEC	MIN SEC	MIN SEC
0	34.48	35.97	36.38	36.80	37.12	37.54	38.00	38.47
0	35.97	36.91	37.94	38.43	39.14	40.01	40.97	41.94
0	36.91	37.94	38.43	39.14	40.01	40.97	41.94	42.91
0	37.94	38.43	39.14	40.01	40.97	41.94	42.91	43.90
0	38.43	39.14	40.01	40.97	41.94	42.91	43.90	44.89
0	39.14	40.01	40.97	41.94	42.91	43.90	44.89	45.88
0	40.01	40.97	41.94	42.91	43.90	44.89	45.88	46.87
0	40.97	41.94	42.91	43.90	44.89	45.88	46.87	47.86
0	41.94	42.91	43.90	44.89	45.88	46.87	47.86	48.85
0	42.91	43.90	44.89	45.88	46.87	47.86	48.85	49.84
0	43.90	44.89	45.88	46.87	47.86	48.85	49.84	50.83
0	44.89	45.88	46.87	47.86	48.85	49.84	50.83	51.82
0	45.88	46.87	47.86	48.85	49.84	50.83	51.82	52.81
0	46.87	47.86	48.85	49.84	50.83	51.82	52.81	53.80
0	47.86	48.85	49.84	50.83	51.82	52.81	53.80	54.79
0	48.85	49.84	50.83	51.82	52.81	53.80	54.79	55.78
0	49.84	50.83	51.82	52.81	53.80	54.79	55.78	56.77
0	50.83	51.82	52.81	53.80	54.79	55.78	56.77	57.76
0	51.82	52.81	53.80	54.79	55.78	56.77	57.76	58.75
0	52.81	53.80	54.79	55.78	56.77	57.76	58.75	59.74
0	53.80	54.79	55.78	56.77	57.76	58.75	59.74	60.73
0	54.79	55.78	56.77	57.76	58.75	59.74	60.73	61.72
0	55.78	56.77	57.76	58.75	59.74	60.73	61.72	62.71
0	56.77	57.76	58.75	59.74	60.73	61.72	62.71	63.70
0	57.76	58.75	59.74	60.73	61.72	62.71	63.70	64.69
0	58.75	59.74	60.73	61.72	62.71	63.70	64.69	65.68
0	59.74	60.73	61.72	62.71	63.70	64.69	65.68	66.67
0	60.73	61.72	62.71	63.70	64.69	65.68	66.67	67.66
0	61.72	62.71	63.70	64.69	65.68	66.67	67.66	68.65
0	62.71	63.70	64.69	65.68	66.67	67.66	68.65	69.64
0	63.70	64.69	65.68	66.67	67.66	68.65	69.64	70.63
0	64.69	65.68	66.67	67.66	68.65	69.64	70.63	71.62
0	65.68	66.67	67.66	68.65	69.64	70.63	71.62	72.61
0	66.67	67.66	68.65	69.64	70.63	71.62	72.61	73.60
0	67.66	68.65	69.64	70.63	71.62	72.61	73.60	74.59
0	68.65	69.64	70.63	71.62	72.61	73.60	74.59	75.58
0	69.64	70.63	71.62	72.61	73.60	74.59	75.58	76.57
0	70.63	71.62	72.61	73.60	74.59	75.58	76.57	77.56
0	71.62	72.61	73.60	74.59	75.58	76.57	77.56	78.55
0	72.61	73.60	74.59	75.58	76.57	77.56	78.55	79.54
0	73.60	74.59	75.58	76.57	77.56	78.55	79.54	80.53
0	74.59	75.58	76.57	77.56	78.55	79.54	80.53	81.52
0	75.58	76.57	77.56	78.55	79.54	80.53	81.52	82.51
0	76.57	77.56	78.55	79.54	80.53	81.52	82.51	83.50
0	77.56	78.55	79.54	80.53	81.52	82.51	83.50	84.49
0	78.55	79.54	80.53	81.52	82.51	83.50	84.49	85.48
0	79.54	80.53	81.52	82.51	83.50	84.49	85.48	86.47
0	80.53	81.52	82.51	83.50	84.49	85.48	86.47	87.46
0	81.52	82.51	83.50	84.49	85.48	86.47	87.46	88.45
0	82.51	83.50	84.49	85.48	86.47	87.46	88.45	89.44
0	83.50	84.49	85.48	86.47	87.46	88.45	89.44	90.43
0	84.49	85.48	86.47	87.46	88.45	89.44	90.43	91.42
0	85.48	86.47	87.46	88.45	89.44	90.43	91.42	92.41
0	86.47	87.46	88.45	89.44	90.43	91.42	92.41	93.40
0	87.46	88.45	89.44	90.43	91.42	92.41	93.40	94.39
0	88.45	89.44	90.43	91.42	92.41	93.40	94.39	95.38
0	89.44	90.43	91.42	92.41	93.40	94.39	95.38	96.37
0	90.43	91.42	92.41	93.40	94.39	95.38	96.37	97.36
0	91.42	92.41	93.40	94.39	95.38	96.37	97.36	98.35
0	92.41	93.40	94.39	95.38	96.37	97.36	98.35	99.34
0	93.40	94.39	95.38	96.37	97.36	98.35	99.34	100.33
0	94.39	95.38	96.37	97.36	98.35	99.34	100.33	101.32
0	95.38	96.37	97.36	98.35	99.34	100.33	101.32	102.31
0	96.37	97.36	98.35	99.34	100.33	101.32	102.31	103.30
0	97.36	98.35	99.34	100.33	101.32	102.31	103.30	104.29
0	98.35	99.34	100.33	101.32	102.31	103.30	104.29	105.28
0	99.34	100.33	101.32	102.31	103.30	104.29	105.28	106.27
0	100.33	101.32	102.31	103.30	104.29	105.28	106.27	107.26
0	101.32	102.31	103.30	104.29	105.28	106.27	107.26	108.25
0	102.31	103.30	104.29	105.28	106.27	107.26	108.25	109.24
0	103.30	104.29	105.28	106.27	107.26	108.25	109.24	110.23
0	104.29	105.28	106.27	107.26	108.25	109.24	110.23	111.22
0	105.28	106.27	107.26	108.25	109.24	110.23	111.22	112.21
0	106.27	107.26	108.25	109.24	110.23	111.22	112.21	113.20
0	107.26	108.25	109.24	110.23	111.22	112.21	113.20	114.19
0	108.25	109.24	110.23	111.22	112.21	113.20	114.19	115.18
0	109.24	110.23	111.22	112.21	113.20	114.19	115.18	116.17
0	110.23	111.22	112.21	113.20	114.19	115.18	116.17	117.16
0	111.22	112.21	113.20	114.19	115.18	116.17	117.16	118.15
0	112.21	113.20	114.19	115.18	116.17	117.16	118.15	119.14
0	113.20	114.19	115.18	116.17	117.16	118.15	119.14	120.13
0	114.19	115.18	116.17	117.16	118.15	119.14	120.13	121.12
0	115.18	116.17	117.16	118.15	119.14	120.13	121.12	122.11
0	116.17	117.16	118.15	119.14	120.13	121.12	122.11	123.10
0	117.16	118.15	119.14	120.13	121.12	122.11	123.10	124.09
0	118.15	119.14	120.13	121.12	122.11	123.10	124.09	125.08
0	119.14	120.13	121.12	122.11	123.10	124.09	125.08	126.07
0	120.13	121.12	122.11	123.10	124.09	125.08	126.07	127.06
0	121.12	122.11	123.10	124.09	125.08	126.07	127.06	128.05
0	122.11	123.10	124.09	125.08	126.07	127.06	128.05	129.04
0	123.10	124.09	125.08	126.07	127.06	128.05	129.04	130.03
0	124.09	125.08	126.07	127.06	128.05	129.04	130.03	131.02
0	125.08	126.07	127.06	128.05	129.04	130.03	131.02	132.01
0	126.07	127.06	128.05	129.04	130.03	131.02	132.01	133.00
0	127.06	128.05	129.04	130.03	131.02	132.01	133.00	134.00
0	128.05	129.04	130.03	131.02	132.01	133.00	134.00	135.00
0	129.04	130.03	131.02	132.01	133.00	134.00	135.00	136.00
0	130.03	131.02	132.01	133.00	134.00	135.00	136.00	137.00
0	131.02	132.01	133.00	134.00	135.00	136.00	137.00	138.00
0	132.01	133.00	134.00	135.00	136.00	137.00	138.00	139.00
0	133.00	134.00	135.00	136.00	137.00	138.00	139.00	140.00
0	134.00	135.00	136.00	137.00	138.00	139.00	140.00	141.00
0	135.00	136.00	137.00	138.00	139.00	140.00	141.00	142.00
0	136.00	137.00	138.00	139.00	140.00	141.00	142.00	143.00
0	137.00	138.00	139.00	140.00	141.00	142.00	143.00	144.00
0	138.00	139.00	140.00	141.00	142.00	143.00	144.00	145.00
0	139.00	140.00	141.00	142.00	143.00	144.00	145.00	146.00
0	140.00	141.00	142.00	143.00	144.00	145.00	146.00	147.00
0	141.00	142.00	143.00	144.00	145.00	146.00	147.00	148.00
0	142.00	143.00	144.00	145.00	146.00	147.00	148.00	149.00
0	143.00	144.00	145.00	146.00	147.00	148.00	149.00	150.00
0	144.00	145.00	146.00	147.00	148.00	149.00	150.00	151.00
0	145.00	146.00	147.00	148.00	149.00	150.00	151.00	152.00
0	146.00	147.00	148.00	149.00	150.00	151.00	152.00	153.00
0	147.00	148.00	149.00	150.00	151.00	152.00	153.00	154.00
0	148.00	149.00	150.00</td					

TABLE II
DEPTH ALLOWANCES FOR PKP-AB BRANCH
(JORDAN AND ANDERSON MODEL B1)

DELT P	(m) BP SUBTRACTED FROM 0 DEPTH TRAVEL TIMES)						
	100	200	300	400	500	600	700
85	24.58	33.49	43.36	53.29	63.21	73.19	83.74
79	24.44	33.34	43.22	53.12	63.02	72.91	82.73
76	24.44	33.34	43.22	53.12	63.02	72.91	82.73
75	24.44	33.34	43.22	53.12	63.02	72.91	82.73
73	24.44	33.34	43.22	53.12	63.02	72.91	82.73
71	24.44	33.34	43.22	53.12	63.02	72.91	82.73
70	24.44	33.34	43.22	53.12	63.02	72.91	82.73
68	24.44	33.34	43.22	53.12	63.02	72.91	82.73
67	24.44	33.34	43.22	53.12	63.02	72.91	82.73
65	24.44	33.34	43.22	53.12	63.02	72.91	82.73
62	24.44	33.34	43.22	53.12	63.02	72.91	82.73
60	24.44	33.34	43.22	53.12	63.02	72.91	82.73
58	24.44	33.34	43.22	53.12	63.02	72.91	82.73
56	24.44	33.34	43.22	53.12	63.02	72.91	82.73
54	24.44	33.34	43.22	53.12	63.02	72.91	82.73
52	24.44	33.34	43.22	53.12	63.02	72.91	82.73
50	24.44	33.34	43.22	53.12	63.02	72.91	82.73
48	24.44	33.34	43.22	53.12	63.02	72.91	82.73
46	24.44	33.34	43.22	53.12	63.02	72.91	82.73
44	24.44	33.34	43.22	53.12	63.02	72.91	82.73
42	24.44	33.34	43.22	53.12	63.02	72.91	82.73
40	24.44	33.34	43.22	53.12	63.02	72.91	82.73
38	24.44	33.34	43.22	53.12	63.02	72.91	82.73
36	24.44	33.34	43.22	53.12	63.02	72.91	82.73
34	24.44	33.34	43.22	53.12	63.02	72.91	82.73
32	24.44	33.34	43.22	53.12	63.02	72.91	82.73
30	24.44	33.34	43.22	53.12	63.02	72.91	82.73
28	24.44	33.34	43.22	53.12	63.02	72.91	82.73
26	24.44	33.34	43.22	53.12	63.02	72.91	82.73
24	24.44	33.34	43.22	53.12	63.02	72.91	82.73
22	24.44	33.34	43.22	53.12	63.02	72.91	82.73
20	24.44	33.34	43.22	53.12	63.02	72.91	82.73
18	24.44	33.34	43.22	53.12	63.02	72.91	82.73
16	24.44	33.34	43.22	53.12	63.02	72.91	82.73
14	24.44	33.34	43.22	53.12	63.02	72.91	82.73
12	24.44	33.34	43.22	53.12	63.02	72.91	82.73
10	24.44	33.34	43.22	53.12	63.02	72.91	82.73
8	24.44	33.34	43.22	53.12	63.02	72.91	82.73
6	24.44	33.34	43.22	53.12	63.02	72.91	82.73
4	24.44	33.34	43.22	53.12	63.02	72.91	82.73
2	24.44	33.34	43.22	53.12	63.02	72.91	82.73
0	24.44	33.34	43.22	53.12	63.02	72.91	82.73

TABLE II (Continued)

		(TO BE SUBTRACTED FROM 0 DEPTH TRAVEL TIMES)							
		100	200	300	400	500	600	700	800
DELTA	145	12.87	24.70	36.24	47.44	57.73	67.56	76.88	85.45
	146	12.99	24.88	36.44	47.71	58.03	67.88	77.23	85.83
147	13.00	24.91	36.49	47.78	59.14	68.02	77.39	86.02	
	13.03	24.96	36.57	47.87	59.23	68.13	77.51	86.15	
148	13.03	24.97	36.58	47.90	58.28	68.19	77.59	86.25	
	149	13.04	24.99	36.62	47.95	58.35	68.28	77.70	86.38
150	13.04	25.02	36.66	48.01	58.42	68.36	77.80	86.50	
	151	13.06	25.04	36.69	48.05	58.48	68.44	77.90	86.62
152	13.07	25.06	36.73	48.10	58.54	68.52	77.99	86.73	
	153	13.09	25.09	36.77	48.15	58.61	68.60	78.09	86.85
154	13.09	25.10	36.79	48.19	58.66	68.67	78.17	86.95	
	155	13.11	25.13	36.83	48.24	58.72	68.74	78.26	87.05
156	13.11	25.15	36.86	48.28	58.77	68.80	78.34	87.15	
	157	13.12	25.17	36.89	49.00	0.0	0.0	0.0	0.0
158	13.12								

TABLE II (Continued)

DEPTH ALLOWANCES FOR PKP-CD BRANCH
(JORDAN AND ANDERSON MODEL B1)

(TO BE SUBTRACTED FROM 0 DEPTH TRAVEL TIMES)

DELTA	100	200	300	400	500	600	700	800
110	13.16	25.23	36.98	48.45	58.99	69.07	78.55	87.51
111	13.15	25.22	36.98	48.44	58.98	69.06	78.64	87.49
112	13.16	25.23	36.98	48.44	58.98	69.06	78.63	87.49
113	13.15	25.23	36.98	48.44	58.97	69.04	78.62	87.48
114	13.15	25.22	36.97	48.43	58.97	69.04	78.62	87.47
115	13.15	25.22	36.97	48.43	58.97	69.04	78.61	87.46
116	13.15	25.22	36.97	48.42	58.95	69.02	78.60	87.45
117	13.15	25.21	36.96	48.42	58.95	69.01	78.59	87.43
118	13.15	25.21	36.96	48.41	58.94	69.01	78.58	87.43
119	13.15	25.21	36.96	48.41	58.94	69.01	78.58	87.42
120	13.15	25.21	36.95	48.41	58.93	69.00	78.56	87.41
121	13.14	25.21	36.95	48.40	58.93	68.99	78.56	87.40
122	13.15	25.21	36.95	48.40	58.93	68.99	78.56	87.40
123	13.15	25.21	36.95	48.40	58.92	68.98	78.55	87.38
124	13.15	25.21	36.95	48.39	58.92	68.98	78.54	87.38
125	13.14	25.20	36.94	48.39	58.91	68.97	78.53	87.37
126	13.14	25.20	36.94	48.38	58.91	68.96	78.52	87.36
127	13.14	25.20	36.94	48.38	58.90	68.96	78.52	87.35
128	13.14	25.20	36.93	48.38	58.90	68.95	78.51	87.34
129	13.14	25.20	36.94	48.38	58.90	68.95	78.51	87.34
130	13.14	25.20	36.93	48.38	58.90	68.95	78.51	87.33
131	13.14	25.19	36.92	48.37	58.88	68.94	78.49	87.32
132	13.13	25.19	36.92	48.36	58.88	68.93	78.49	87.31
133	13.14	25.19	36.93	48.37	58.88	68.93	78.49	87.31
134	13.14	25.19	36.92	48.37	58.88	68.93	78.48	87.31
135	13.14	25.19	36.92	48.36	58.87	68.92	78.47	87.30
136	13.14	25.19	36.92	48.36	58.87	68.92	78.47	87.30
137	13.14	25.19	36.92	48.36	58.87	68.92	78.47	87.29
138	13.14	25.19	36.92	48.36	58.87	68.92	78.47	87.29
139	13.14	25.19	36.92	48.36	58.87	68.92	78.46	87.28
140	13.14	25.19	36.92	48.35	58.86	68.91	78.46	87.28
141	13.13	25.18	36.91	48.35	58.86	68.90	78.45	87.27
142	13.13	25.18	36.91	48.35	58.86	68.90	78.45	87.27
143	13.13	25.18	36.91	48.35	58.86	68.90	78.45	87.27
144	13.13	25.18	36.91	48.34	58.85	68.90	78.44	87.26
145	13.14	25.19	36.91	48.35	58.86	68.90	78.45	87.26
146	13.13	25.18	36.91	48.34	58.85	68.89	78.44	87.25
147	13.13	25.18	36.90	48.34	58.85	68.89	78.43	87.25
148	13.13	25.18	36.90	48.34	58.84	68.89	78.43	87.25
149	13.13	25.18	36.91	48.34	58.85	68.89	78.43	87.25
150	13.13	25.18	36.90	48.34	58.84	68.89	78.43	87.24
151	13.13	25.18	36.91	48.34	58.85	68.89	78.43	87.25
152	13.14	25.18	36.91	48.34	58.85	68.89	78.43	87.25
153	13.13	25.17	36.90	48.33	58.84	68.88	78.42	87.24
154	13.13	25.18	36.90	48.33	58.84	68.88	78.42	87.24
155	13.13	25.17	36.90	48.33	58.84	68.88	78.42	87.24
156	13.14	25.18	36.91	48.34	58.85	68.89	78.43	87.24
157	13.14	25.18	36.91	48.34	58.85	68.89	78.43	87.24
158	13.13	25.18	36.91	0.0	0.0	0.0	0.0	0.0

TABLE II (Continued)

DEPTH ALLOWANCES FOR PKP-DF BRANCH
(JORDAN AND ANDERSON MODEL B1)

(TO RF SUBTRACTED FROM 0 DEPTH TRAVEL TIMES)

DELTA	100	200	300	400	500	600	700	800
110	13.15	25.23	36.98	48.45	58.99	69.07	78.66	87.52
111	13.16	25.23	36.99	48.45	58.99	69.07	78.66	87.52
112	13.16	25.23	36.99	48.45	58.99	69.07	78.66	87.52
113	13.16	25.23	36.99	48.45	59.00	69.07	78.66	87.52
114	13.16	25.23	36.99	48.45	59.00	69.08	78.66	87.52
115	13.15	25.23	36.98	48.45	58.99	69.07	78.65	87.52
116	13.15	25.23	36.98	48.45	58.99	69.07	78.66	87.52
117	13.16	25.23	36.99	48.45	59.00	69.08	78.66	87.52
118	13.15	25.23	36.98	48.45	58.99	69.07	78.66	87.52
119	13.16	25.24	36.99	48.46	59.00	69.08	78.67	87.53
120	13.16	25.23	36.99	48.46	59.00	69.08	78.67	87.53
121	13.16	25.23	36.99	48.45	59.00	69.08	78.67	87.53
122	13.16	25.23	36.99	48.46	59.00	69.08	78.67	87.54
123	13.16	25.24	37.00	48.46	59.01	69.09	78.68	87.54
124	13.16	25.24	37.00	48.46	59.01	69.09	78.68	87.55
125	13.16	25.24	37.00	48.46	59.01	69.09	78.68	87.55
126	13.16	25.24	37.00	48.47	59.02	69.10	78.69	87.56
127	13.16	25.24	37.00	48.47	59.01	69.10	78.69	87.56
128	13.16	25.24	37.00	48.47	59.02	69.11	78.70	87.57
129	13.16	25.24	37.00	48.47	59.02	69.11	78.70	87.57
130	13.16	25.24	37.00	48.48	59.02	69.11	78.71	87.58
131	13.16	25.24	37.00	48.47	59.03	69.12	78.71	87.58
132	13.16	25.25	37.01	48.48	59.03	69.12	78.72	87.60
133	13.16	25.25	37.01	48.48	59.04	69.13	78.73	87.61
134	13.16	25.25	37.01	49.49	59.04	69.14	78.74	87.61
135	13.17	25.25	37.02	48.50	59.05	69.15	78.75	87.63
136	13.16	25.25	37.02	48.49	59.05	69.15	78.75	87.63
137	13.17	25.26	37.02	48.50	59.06	69.16	78.76	87.65
138	13.17	25.26	37.03	48.51	59.07	69.17	78.78	87.67
139	13.17	25.26	37.03	48.51	59.07	69.18	78.79	87.68
140	13.18	25.27	37.04	48.53	59.09	69.20	78.81	87.70
141	13.18	25.27	37.05	48.53	59.10	69.21	78.82	87.72
142	13.17	25.27	37.05	48.54	59.10	69.21	78.83	87.73
143	13.18	25.27	37.05	48.54	59.12	69.23	78.85	87.75
144	13.18	25.28	37.06	48.56	59.13	69.24	78.87	87.77
145	13.19	25.29	37.07	48.57	59.14	69.26	78.89	87.90
146	13.18	25.28	37.07	48.57	59.14	69.27	78.89	87.81
147	13.19	25.29	37.08	48.58	59.17	69.29	78.93	87.84
148	13.19	25.30	37.09	48.59	59.18	69.31	78.94	87.86
149	13.18	25.30	37.09	48.60	59.19	69.32	78.96	87.88
150	13.20	25.31	37.11	48.62	59.21	69.34	78.99	87.92
151	13.19	25.31	37.12	48.63	59.23	69.37	79.02	87.96
152	13.20	25.32	37.13	48.65	59.25	69.40	79.05	88.00
153	13.20	25.33	37.14	48.66	59.27	69.42	79.08	88.03
154	13.20	25.33	37.14	48.67	59.28	69.44	79.11	88.06
155	13.21	25.34	37.16	48.69	59.31	69.47	79.14	88.10
156	13.21	25.35	37.17	48.71	59.33	69.50	79.18	88.14
157	13.22	25.36	37.19	48.73	59.35	69.52	79.21	88.19
158	13.22	25.37	37.20	48.74	59.37	69.55	79.24	88.22
159	13.22	25.37	37.20	48.76	59.39	69.57	79.27	88.26
160	13.22	25.38	37.22	48.77	59.41	69.60	79.31	88.30
161	13.23	25.39	37.23	48.79	59.44	69.63	79.34	88.35
162	13.23	25.39	37.24	48.80	59.45	69.65	79.37	88.38
163	13.23	25.40	37.25	48.81	59.47	69.67	79.39	88.41
164	13.24	25.41	37.27	48.84	59.50	69.70	79.43	88.45
165	13.25	25.42	37.27	48.85	59.51	69.73	79.46	88.48
166	13.24	25.42	37.28	48.86	59.53	69.74	79.48	88.51
167	13.24	25.42	37.29	48.87	59.54	69.76	79.50	88.54
168	13.25	25.43	37.30	48.88	59.56	69.79	79.53	88.57
169	13.26	25.44	37.31	48.90	59.58	69.81	79.56	88.60
170	13.26	25.45	37.32	48.91	59.60	69.83	79.58	88.63
171	13.26	25.44	37.32	48.91	59.60	69.84	79.59	88.64
172	13.26	25.45	37.33	48.92	59.61	69.85	79.61	88.66
173	13.26	25.46	37.34	48.93	59.63	69.87	79.63	88.68
174	13.27	25.46	37.34	48.94	59.64	69.88	79.64	88.70
175	13.26	25.46	37.34	48.94	59.64	69.89	79.65	88.71
176	13.26	25.46	37.35	48.95	59.64	69.89	79.66	88.72
177	13.27	25.47	37.36	48.96	59.66	69.91	79.67	88.74
178	13.26	25.46	37.35	48.95	59.65	69.90	79.67	88.74
179	13.27	25.47	37.36	48.96	59.66	69.91	79.68	88.75
180	13.26	25.46	37.35	48.96	59.66	69.91	79.68	88.74

TABLE III

TRAVEL TIME DIFFERENCES OF PKP BRANCH
(JOPDAN AND ANDERSON MODEL B1)

DEPTH = 0 KM

DELTA	AB-CD	AB-BC	AB-DF	CD-BC	CD-DF	BC-DF
110					0.0	
111					0.0	
112					0.02	
113					0.04	
114					0.07	
115					0.12	
116					0.16	
117					0.21	
118					0.28	
119					0.35	
120					0.43	
121					0.52	
122					0.62	
123					0.72	
124					0.84	
125					0.96	
126					1.09	
127					1.24	
128					1.39	
129					1.56	
130					1.73	
131					1.91	
132					2.10	
133					2.31	
134					2.53	
135					2.75	
136					3.00	
137					3.25	
138					3.52	
139					3.81	
140					4.10	
141					4.41	
142					4.75	
143					5.10	
144					5.46	
145	-6.59	0.01	-0.74	6.60	5.85	-0.75
146	-4.98	0.46	1.28	5.44	6.26	0.82
147	-3.24	1.34	3.44	4.58	6.68	2.10
148	-1.40	2.41	5.73	3.81	7.13	3.32
149	0.51	3.66	8.13	3.15	7.62	4.47
150	2.49	5.01	10.60	2.52	8.11	5.59
151	4.50	6.47	13.15	1.97	8.65	6.68
152	6.55	8.04	15.77	1.49	9.22	7.73
153	8.65	9.72	18.47	1.07	9.82	8.75
154	10.78	11.50	21.25	0.72	10.47	9.75
155	12.93	13.38	24.08	0.45	11.15	10.70
156	15.10	15.35	26.98	0.25	11.88	11.63
157	17.31	17.41	29.95	0.10	12.64	12.54
158	19.53	19.55	32.98	0.02	13.45	13.43
159			36.09			
160			39.25			
161			42.49			
162			45.79			
163			49.15			
164			52.56			
165			56.04			
166			59.59			
167			63.19			
168			66.85			
169			70.57			
170			74.35			
171			78.21			
172			82.13			
173			86.11			
174			90.15			
175			94.27			
176			98.45			
177			102.69			

TABLE III (Continued)

TRAVEL TIME DIFFERENCES OF PKP BRANCH
(JORDAN AND ANDERSON MODEL B1)

DEPTH = 100 KM

DELT A	AB-CD	AB-BC	AB-DF	CD-BC	CD-DF	BC-DF
110					-0.01	
111					0.01	
112					0.02	
113					0.05	
114					0.08	
115					0.12	
116					0.16	
117					0.22	
118					0.29	
119					0.36	
120					0.44	
121					0.54	
122					0.63	
123					0.73	
124					0.95	
125					0.98	
126					1.11	
127					1.26	
128					1.41	
129					1.58	
130					1.75	
131					1.93	
132					2.13	
133					2.33	
134					2.55	
135					2.78	
136					3.02	
137					3.28	
138					3.55	
139					3.84	
140					4.14	
141					4.46	
142					4.79	
143					5.15	
144					5.51	
145	-6.30	0.03	-0.40	6.33	5.90	-0.43
146	-4.67	0.63	1.64	5.30	6.31	1.01
147	-2.90	1.55	3.84	4.45	6.74	2.29
148	-1.03	2.68	6.16	3.71	7.19	3.48
149	0.89	3.94	8.56	3.05	7.67	4.62
150	2.88	5.31	11.06	2.43	8.18	5.75
151	4.90	6.80	13.61	1.90	8.71	6.81
152	6.98	8.40	16.26	1.42	9.28	7.86
153	9.08	10.09	18.97	1.01	9.39	8.88
154	11.21	11.89	21.75	0.68	10.54	9.86
155	13.37	13.78	24.60	0.41	11.23	10.92
156	15.56	15.78	27.51	0.22	11.95	11.73
157	17.77	17.85	30.49	0.08	12.72	12.64
158	19.99	20.00	33.53	0.01	13.54	13.53
159			36.64			
160			39.82			
161			43.07			
162			46.37			
163			49.74			
164			53.16			
165			56.65			
166			60.19			
167			63.79			
168			67.46			
169			71.19			
170			74.98			
171			78.84			
172			82.76			
173			86.74			
174			90.79			
175			94.90			
176			99.09			
177			103.34			

TABLE III (Continued)

TRAVEL TIME DIFFERENCES OF PKP BRANCH
(JORDAN AND ANDERSON MODEL B1)

DEPTH = 200 KM

DELTA	AB-CD	AB-BC	AB-DF	CD-RC	CD-DF	BC-DF
110					0.0	
111					0.01	
112					0.02	
113					0.04	
114					0.08	
115					0.13	
116					0.17	
117					0.23	
118					0.30	
119					0.38	
120					0.45	
121					0.54	
122					0.64	
123					0.75	
124					0.87	
125					1.00	
126					1.13	
127					1.28	
128					1.43	
129					1.60	
130					1.77	
131					1.96	
132					2.16	
133					2.37	
134					2.59	
135					2.81	
136					3.06	
137					3.32	
138					3.59	
139					3.88	
140					4.18	
141					4.50	
142					4.84	
143					5.19	
144					5.56	
145	-5.98	0.13	-0.03	6.11	5.95	-0.16
146	-4.30	0.84	2.06	5.14	6.36	1.22
147	-2.50	1.81	4.29	4.31	6.79	2.48
148	-0.61	2.98	6.64	3.59	7.25	3.66
149	1.33	4.27	9.07	2.94	7.74	4.80
150	3.33	5.66	11.57	2.33	8.24	5.91
151	5.37	7.18	14.15	1.81	8.78	6.97
152	7.44	8.79	16.80	1.35	9.36	8.01
153	9.55	10.51	19.53	0.96	9.98	9.02
154	11.71	12.34	22.33	0.63	10.62	9.99
155	13.87	14.25	25.19	0.38	11.32	10.94
156	16.06	16.26	28.11	0.20	12.05	11.85
157	18.28	18.35	31.10	0.07	12.82	12.75
158	20.52	20.53	34.16	0.01	13.64	13.63
159			37.27			
160			40.46			
161			43.71			
162			47.02			
163			50.40			
164			53.82			
165			57.32			
166			60.87			
167			64.47			
168			68.14			
169			71.88			
170			75.67			
171			79.53			
172			83.46			
173			87.45			
174			91.50			
175			95.62			
176			99.80			

TABLE III (Continued)

TRAVEL TIME DIFFERENCES OF PKP BRANCH
(JORDAN AND ANDERSON MODEL B1)

DEPTH = 300 KM

DELTA	AB-CD	AB-BC	AB-DF	CD-BC	CD-DF	BC-DF
110					0.0	
111					0.01	
112					0.03	
113					0.05	
114					0.09	
115					0.13	
116					0.17	
117					0.24	
118					0.30	
119					0.38	
120					0.47	
121					0.56	
122					0.66	
123					0.77	
124					0.89	
125					1.02	
126					1.15	
127					1.30	
128					1.46	
129					1.62	
130					1.80	
131					1.99	
132					2.19	
133					2.39	
134					2.62	
135					2.85	
136					3.10	
137					3.35	
138					3.63	
139					3.92	
140					4.22	
141					4.55	
142					4.89	
143					5.24	
144					5.61	
145	-5.63	0.27	0.38	5.90	6.01	0.11
146	-3.90	1.07	2.52	4.97	6.42	1.45
147	-2.08	2.09	4.78	4.17	6.86	2.69
148	-0.17	3.31	7.15	3.48	7.32	3.84
149	1.80	4.62	9.60	2.82	7.80	4.98
150	3.80	6.04	12.12	2.24	8.32	6.08
151	5.86	7.58	14.72	1.72	8.86	7.14
152	7.95	9.22	17.39	1.27	9.44	8.17
153	10.07	10.97	20.13	0.90	10.06	9.16
154	12.22	12.81	22.93	0.59	10.71	10.12
155	14.40	14.74	25.81	0.34	11.41	11.07
156	16.61	16.78	28.75	0.17	12.14	11.97
157	18.83	18.88	31.75	0.05	12.92	12.87
158	21.07	21.07	34.81	0.0	13.74	13.74
159			37.93			
160			41.14			
161			44.40			
162			47.72			
163			51.10			
164			54.54			
165			58.02			
166			61.58			
167			65.20			
168			68.87			
169			72.61			
170			76.41			
171			80.27			
172			84.20			
173			88.20			
174			92.25			
175			96.37			
176			100.57			

TABLE III (Continued)

TRAVEL TIME DIFFERENCES OF PKD BRANCH
(JORDAN AND ANDERSON MODEL B1)

DEPTH = 400 KM

DELTAS	AB-CD	AB-BC	AB-DF	CD-BC	CD-DF	BC-DF
110					0.0	
111					0.01	
112					0.03	
113					0.05	
114					0.09	
115					0.14	
116					0.19	
117					0.24	
118					0.32	
119					0.40	
120					0.48	
121					0.57	
122					0.68	
123					0.78	
124					0.91	
125					1.03	
126					1.18	
127					1.33	
128					1.48	
129					1.65	
130					1.83	
131					2.01	
132					2.22	
133					2.42	
134					2.65	
135					2.89	
136					3.13	
137					3.39	
138					3.67	
139					3.96	
140					4.28	
141					4.59	
142					4.94	
143					5.29	
144	-6.85	0.01	-1.17	6.86	5.68	-1.18
145	-5.23	0.46	0.84	5.69	6.07	0.38
146	-3.47	1.34	3.02	4.81	6.49	1.68
147	-1.62	2.40	5.30	4.02	6.92	2.90
148	0.31	3.65	7.69	3.34	7.38	4.04
149	2.29	5.00	10.17	2.71	7.88	5.17
150	4.32	6.45	12.71	2.13	8.39	6.26
151	6.39	8.03	15.33	1.64	8.94	7.30
152	8.49	9.69	18.02	1.20	9.53	8.33
153	10.62	11.46	20.77	0.84	10.15	9.31
154	12.78	13.32	23.59	0.54	10.81	10.27
155	14.97	15.28	26.48	0.31	11.51	11.20
156	17.18	17.33	29.43	0.15	12.25	12.10
157	19.41	19.45	32.44	0.04	13.03	12.99
158	19.41		35.51		13.03	
159			38.66			
160			41.85			
161			45.13			
162			48.45			
163			51.84			
164			55.29			
165			58.79			
166			62.35			
167			65.97			
168			69.64			
169			73.39			
170			77.19			
171			81.06			
172			84.99			
173			88.98			
174			93.04			
175			97.17			
176			101.37			

TABLE III (Continued)

TRAVEL TIME DIFFERENCES OF PKP BRANCH
(JORDAN AND ANDERSON MODEL B1)

DEPTH = 500 KM

DELTA	AB-CD	AB-BC	AB-DF	CD-PC	CD-DF	BC-DF
110					0.0	
111					0.01	
112					0.03	
113					0.07	
114					0.10	
115					0.14	
116					0.20	
117					0.26	
118					0.33	
119					0.41	
120					0.50	
121					0.59	
122					0.69	
123					0.81	
124					0.93	
125					1.06	
126					1.20	
127					1.35	
128					1.51	
129					1.68	
130					1.85	
131					2.06	
132					2.25	
133					2.47	
134					2.69	
135					2.93	
136					3.18	
137					3.44	
138					3.72	
139					4.01	
140					4.33	
141					4.65	
142					4.99	
143					5.36	
144	-6.45	0.07	-0.71	6.52	5.74	-0.78
145	-4.76	0.71	1.37	5.47	6.13	0.66
146	-2.97	1.65	3.58	4.62	6.55	1.93
147	-1.08	2.79	5.92	3.87	7.00	3.13
148	0.86	4.06	8.33	3.20	7.47	4.27
149	2.86	5.44	10.82	2.58	7.96	5.38
150	4.91	6.94	13.39	2.03	8.48	6.45
151	6.99	8.53	16.02	1.54	9.03	7.49
152	9.11	10.23	18.73	1.12	9.62	8.50
153	11.25	12.02	21.50	0.77	10.25	9.48
154	13.42	13.91	24.33	0.49	10.91	10.42
155	15.62	15.89	27.24	0.27	11.62	11.35
156	17.84	17.96	30.20	0.12	12.36	12.24
157	20.08	20.10	33.22	0.02	13.14	13.12
158	20.08		36.31		13.14	
159			39.45			
160			42.67			
161			45.96			
162			49.29			
163			52.69			
164			56.14			
165			59.64			
166			63.22			
167			66.84			
168			70.52			
169			74.27			
170			78.09			
171			81.95			
172			85.89			
173			89.90			
174			93.96			
175			98.09			

TABLE III (Continued)

TRAVEL TIME DIFFERENCES OF PKP BRANCH
(JORDAN AND ANDERSON MODEL B1)

DEPTH = 600 KM

DELTA	AB-CD	AB-BC	AB-DF	CD-BC	CD-DF	BC-DF
110					0.0	
111					0.01	
112					0.03	
113					0.07	
114					0.11	
115					0.15	
116					0.21	
117					0.28	
118					0.34	
119					0.42	
120					0.51	
121					0.71	
122					0.83	
123					0.95	
124					1.08	
125					1.23	
126					1.38	
127					1.55	
128					1.72	
129					1.89	
130					2.09	
131					2.29	
132					2.51	
133					2.74	
134					2.98	
135					3.23	
136					3.49	
137					3.77	
138					4.07	
139					4.39	
140					4.72	
141					5.06	
142					5.43	
143					5.80	-0.41
144	-5.98	0.23	-0.18	6.21	6.21	0.95
145	-4.25	1.01	1.96	5.26	6.64	2.21
146	-2.42	2.01	4.22	4.43	7.08	3.37
147	-0.50	3.21	6.58	3.71	7.55	4.50
148	1.48	4.53	9.03	3.05	8.05	5.60
149	3.49	5.94	11.54	2.45	8.56	6.65
150	5.56	7.47	14.12	1.91	9.13	7.69
151	7.65	9.09	16.78	1.44	9.73	8.69
152	9.78	10.82	19.51	1.04	10.36	9.65
153	11.94	12.65	22.30	0.71	11.03	10.59
154	14.12	14.56	25.15	0.44	11.74	11.50
155	16.32	16.56	28.06	0.24	12.49	12.39
156	18.55	18.65	31.04	0.10	13.27	13.26
157	20.80	20.81	34.07	0.01		
158	20.80		37.18		13.27	
159			40.33			
160			43.57			
161			46.86			
162			50.20			
163			53.60			
164			57.06			
165			60.58			
166			64.15			
167			67.78			
168			71.48			
169			75.23			
170			79.05			
171			82.93			
172			86.86			
173			90.88			
174			94.94			
175			99.08			

TABLE III (Continued)

TRAVEL TIME DIFFERENCES OF PKP BRANCH
(JORDAN AND ANDERSON MODEL B1)

DEPTH = 700 KM

DELTA	AB-CD	AB-BC	AB-DF	CD-BC	CD-DF	BC-DF
110					0.01	
111					0.02	
112					0.05	
113					0.08	
114					0.11	
115					0.16	
116					0.22	
117					0.28	
118					0.36	
119					0.44	
120					0.54	
121					0.63	
122					0.73	
123					0.85	
124					0.98	
125					1.11	
126					1.26	
127					1.41	
128					1.58	
129					1.75	
130					1.93	
131					2.13	
132					2.33	
133					2.55	
134					2.79	
135					3.03	
136					3.28	
137					3.54	
138					3.83	
139					4.14	
140					4.45	
141					4.78	
142					5.13	
143	-7.09	0.01	-1.59	7.10	5.50	-1.60
144	-5.45	0.48	0.44	5.93	5.89	-0.04
145	-3.66	1.37	2.63	5.03	6.29	1.26
146	-1.78	2.45	4.93	4.23	6.71	2.48
147	0.15	3.69	7.33	3.54	7.18	3.64
148	2.15	5.04	9.79	2.89	7.64	4.75
149	4.19	6.50	12.34	2.31	8.15	5.84
150	6.27	8.06	14.94	1.79	8.67	6.88
151	8.38	9.72	17.62	1.34	9.24	7.90
152	10.52	11.48	20.36	0.96	9.84	8.88
153	12.69	13.33	23.17	0.64	10.48	9.84
154	14.89	15.28	26.05	0.39	11.16	10.77
155	17.11	17.31	28.98	0.20	11.87	11.67
156	19.35	19.43	31.98	0.08	12.63	12.55
157	21.60	21.61	35.02	0.01	13.42	13.41
158	21.60		38.13		13.42	
159			41.31			
160			44.56			
161			47.85			
162			51.21			
163			54.61			
164			58.08			
165			61.61			
166			65.19			
167			68.83			
168			72.52			
169			76.29			
170			80.11			
171			83.99			
172			87.94			
173			91.95			
174			96.02			

TABLE III (Continued)

TRAVEL TIME DIFFERENCES OF PKP BRANCH
(JORDAN AND ANDERSON MODEL B1)

DEPTH = 800 KM

DELTA	AB-CD	AB-BC	AB-DF	CD-BC	CD-DF	BC-DF
110					0.01	
111					0.03	
112					0.05	
113					0.08	
114					0.12	
115					0.18	
116					0.23	
117					0.30	
118					0.37	
119					0.46	
120					0.55	
121					0.65	
122					0.76	
123					0.88	
124					1.01	
125					1.14	
126					1.29	
127					1.45	
128					1.62	
129					1.79	
130					1.98	
131					2.17	
132					2.39	
133					2.61	
134					2.83	
135					3.08	
136					3.33	
137					3.61	
138					3.90	
139					4.21	
140					4.52	
141					4.86	
142					5.21	
143	-6.53	0.14	-0.95	6.67	5.58	-1.09
144	-4.81	0.83	1.16	5.64	5.97	0.33
145	-2.98	1.81	3.41	4.79	6.39	1.60
146	-1.07	2.95	5.75	4.02	6.82	2.80
147	0.91	4.26	8.18	3.35	7.27	3.92
148	2.93	5.64	10.67	2.71	7.74	5.03
149	4.99	7.14	13.24	2.15	8.25	6.10
150	7.08	8.74	15.87	1.66	8.79	7.13
151	9.22	10.44	18.58	1.22	9.36	8.14
152	11.38	12.24	21.35	0.86	9.97	9.11
153	13.56	14.12	24.17	0.56	10.61	10.05
154	15.77	16.10	27.06	0.33	11.29	10.96
155	18.00	18.16	30.01	0.16	12.01	11.85
156	20.24	20.30	33.02	0.06	12.78	12.72
157	22.51	22.52	36.10	0.01	13.59	13.58
158	22.51		39.21		13.59	
159			42.41			
160			45.66			
161			48.98			
162			52.35			
163			55.77			
164			59.24			
165			62.77			
166			66.36			
167			70.01			
168			73.71			
169			77.48			
170			81.31			
171			85.19			
172			89.14			
173			93.16			
174			97.24			

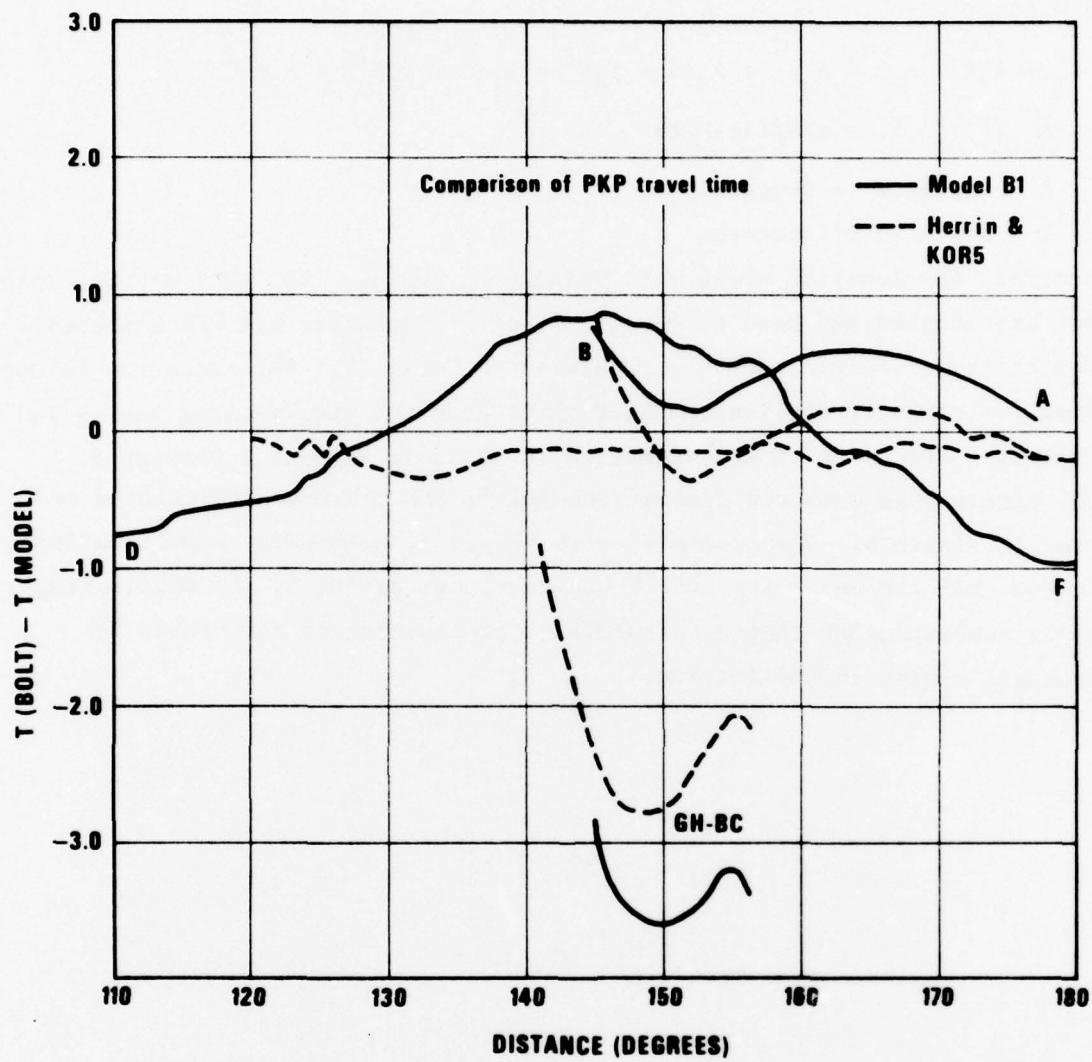


Figure 1. Comparison of theoretical PKP travel times with Bolt's PKP table.

POLYNOMIAL APPROXIMATION OF PKP TRAVEL TIMES

Teledyne Geotech (1968) developed a scheme to fit phase travel times with a polynomial approximation formula. The approximation equation was of the form:

$$T = A_1 + A_2\Delta + A_3h + A_4\Delta^2 + A_5\Delta h + A_6h^2 + A_7\Delta^3 + A_8\Delta^2h + A_9\Delta h^2$$

where A_i ($i = 1, 9$) = coefficients

Δ = distance in degrees

h = depth in kilometers.

In general, the equation works well without A_8 and A_9 . For this report, this method was adopted and used to compute 7 coefficients for all PKP branches. Values of these coefficients are tabulated in Table IV. This equation is convenient for computer application because it does not require long tables in the memory. The error of approximation is shown in Figures 2 through 5. Travel time errors compared against the Bolt's PKP table are calculated and plotted in Figure 6. When compared with Figure 1, polynomial approximations are worse than tables at the end of branches, but better in the middle range, a result demonstrating that a polynomial approximation is comparable to theoretical tables in application.

Geotech, 1968, Equations for computing phase travel-times, Appendix 3 to
Technical Report No. 68-28, Garland, Texas.

TABLE IV

Coefficients for PKP travel times with polynomial approximation equation
 $T = A_1 + A_2 \Delta + A_3 h + A_4 \Delta^2 + A_5 \Delta h + A_6 h^2 + A_7 \Delta^3$

	PKP-AB	PKP-BC	PKP-CD	PKP-DF
A1	2.1874609×10^3	-1.1490044×10^3	1.0514683×10^3	1.3269504×10^3
A2	-2.5718964×10^1	3.4283463×10^1	-1.3772001×10^0	-8.2053394×10^0
A3	$-1.3882348 \times 10^{-1}$	-1.0637046×10^1	$-1.3236269 \times 10^{-1}$	$-1.2812320 \times 10^{-1}$
A4	1.8305379×10^{-1}	$-1.6313869 \times 10^{-1}$	2.3578446×10^{-3}	8.0502689×10^{-2}
A5	6.9567846×10^{-5}	$-1.5998328 \times 10^{-4}$	7.2037537×10^{-6}	$-2.6079055 \times 10^{-5}$
A6	3.1252393×10^{-5}	2.8213491×10^{-5}	2.7949800×10^{-5}	2.7583501×10^{-5}
A7	$-3.7085824 \times 10^{-4}$	2.5747227×10^{-4}	$-5.3665892 \times 10^{-5}$	$-2.1368316 \times 10^{-4}$

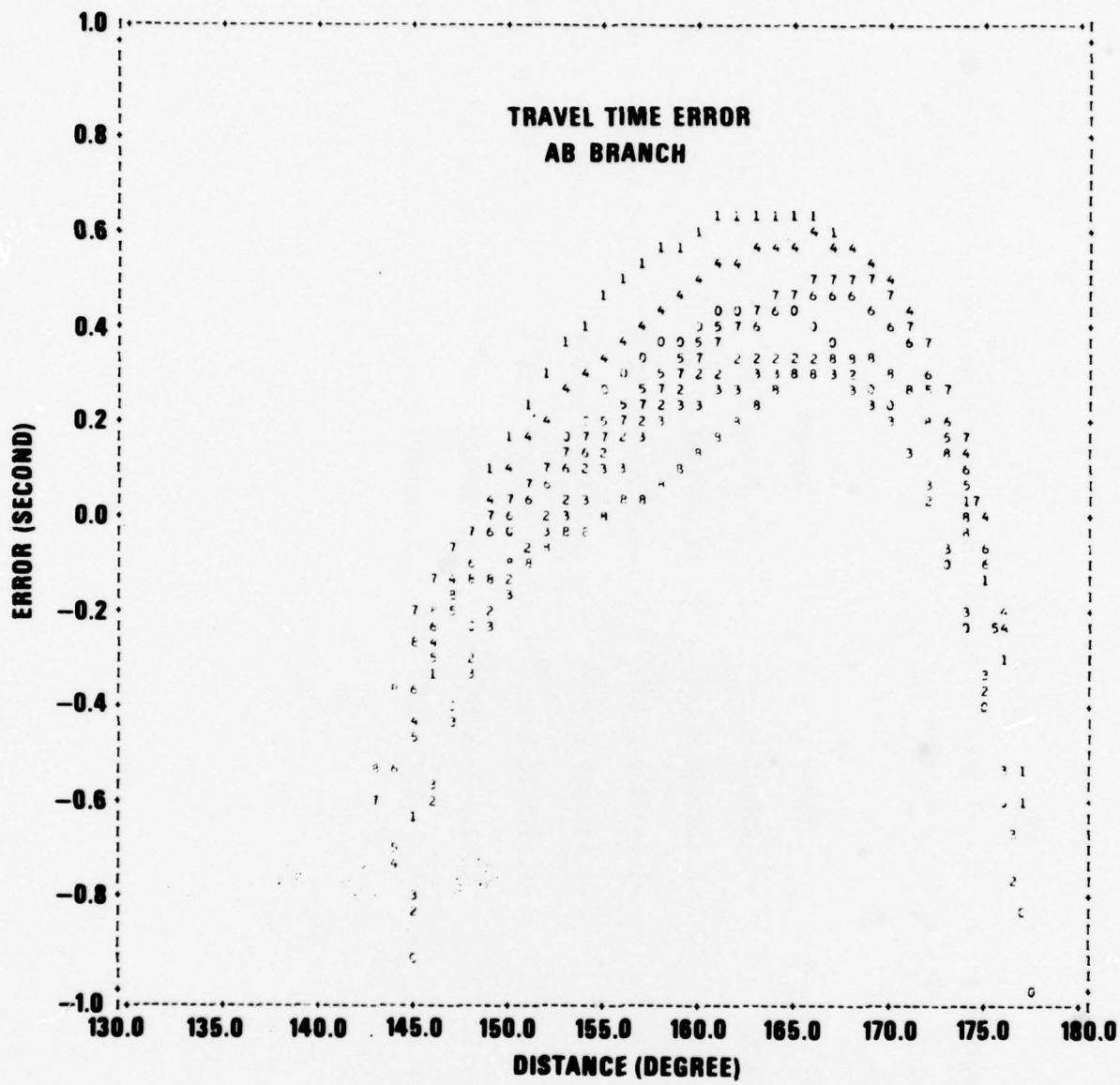


Figure 2. Travel time errors of PKP-AB branch computed with polynomial approximation. Numbers indicate depth of epicenter in hundreds of kilometers.

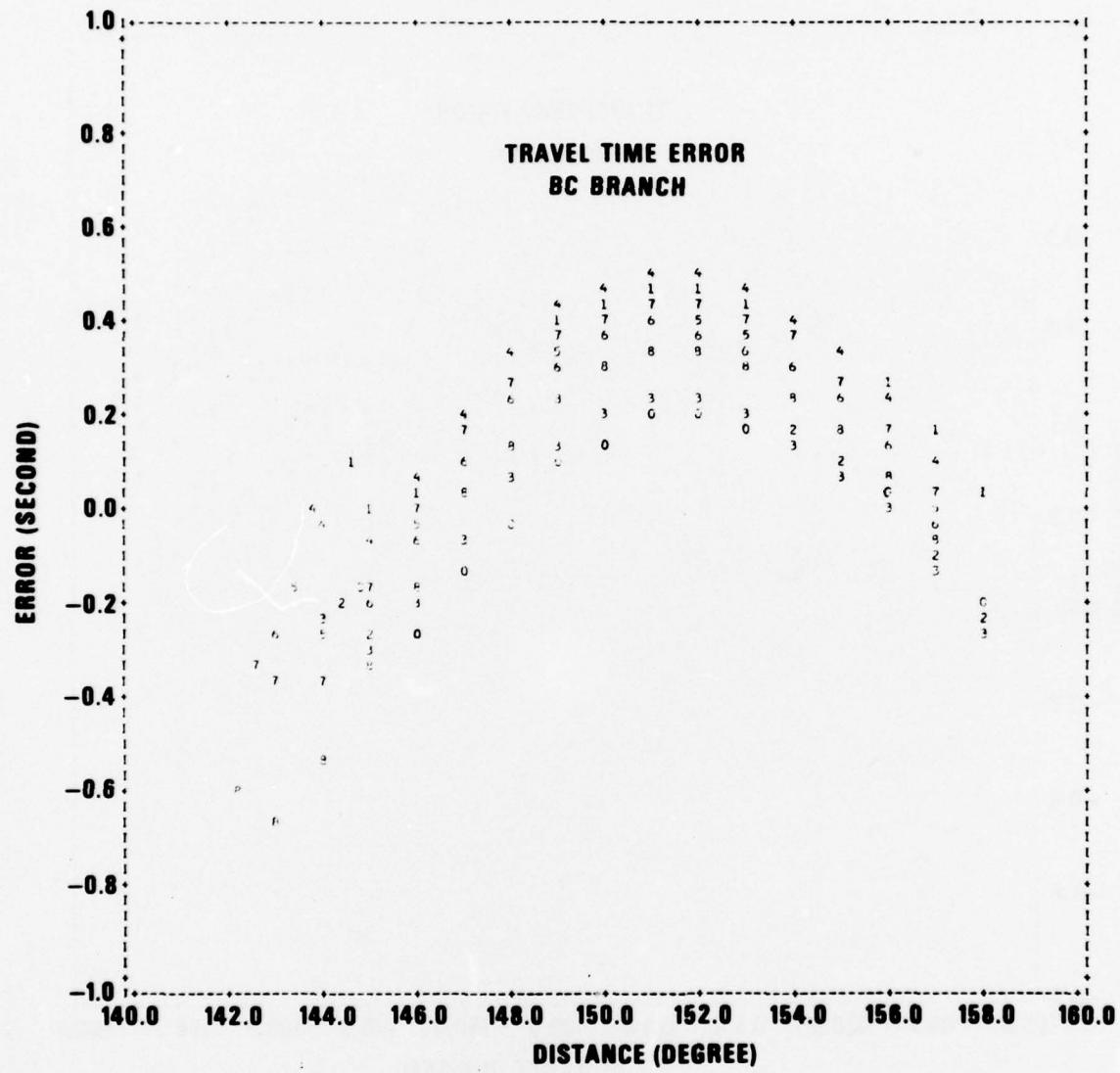


Figure 3. Travel time errors of PKP-BC branch computed with polynomial approximation. Numbers indicate depth of epicenter in hundreds of kilometers.

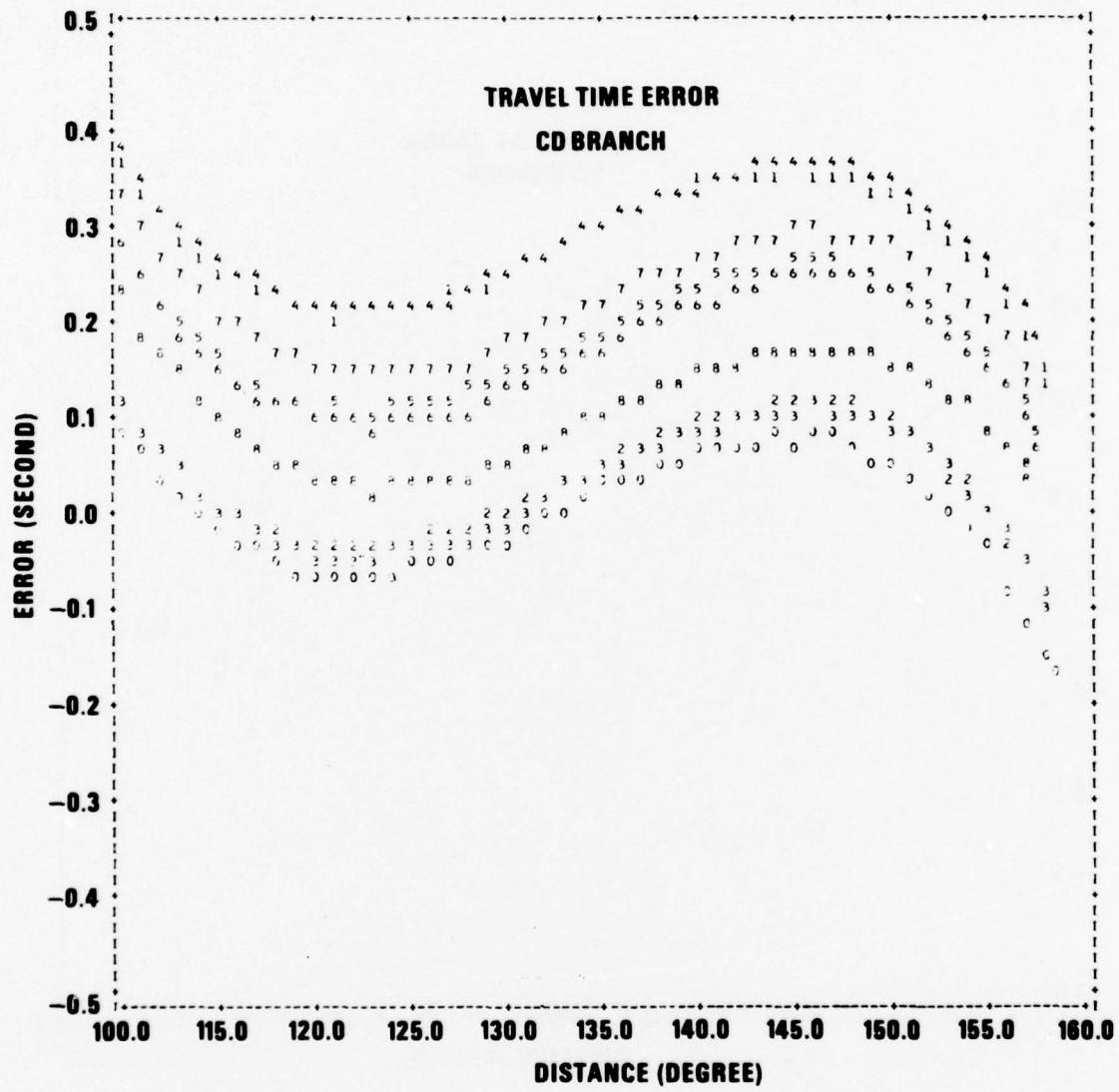


Figure 4. Travel time errors of PKP-CD branch computed with polynomial approximation. Numbers indicate depth of epicenter in hundreds of kilometers.

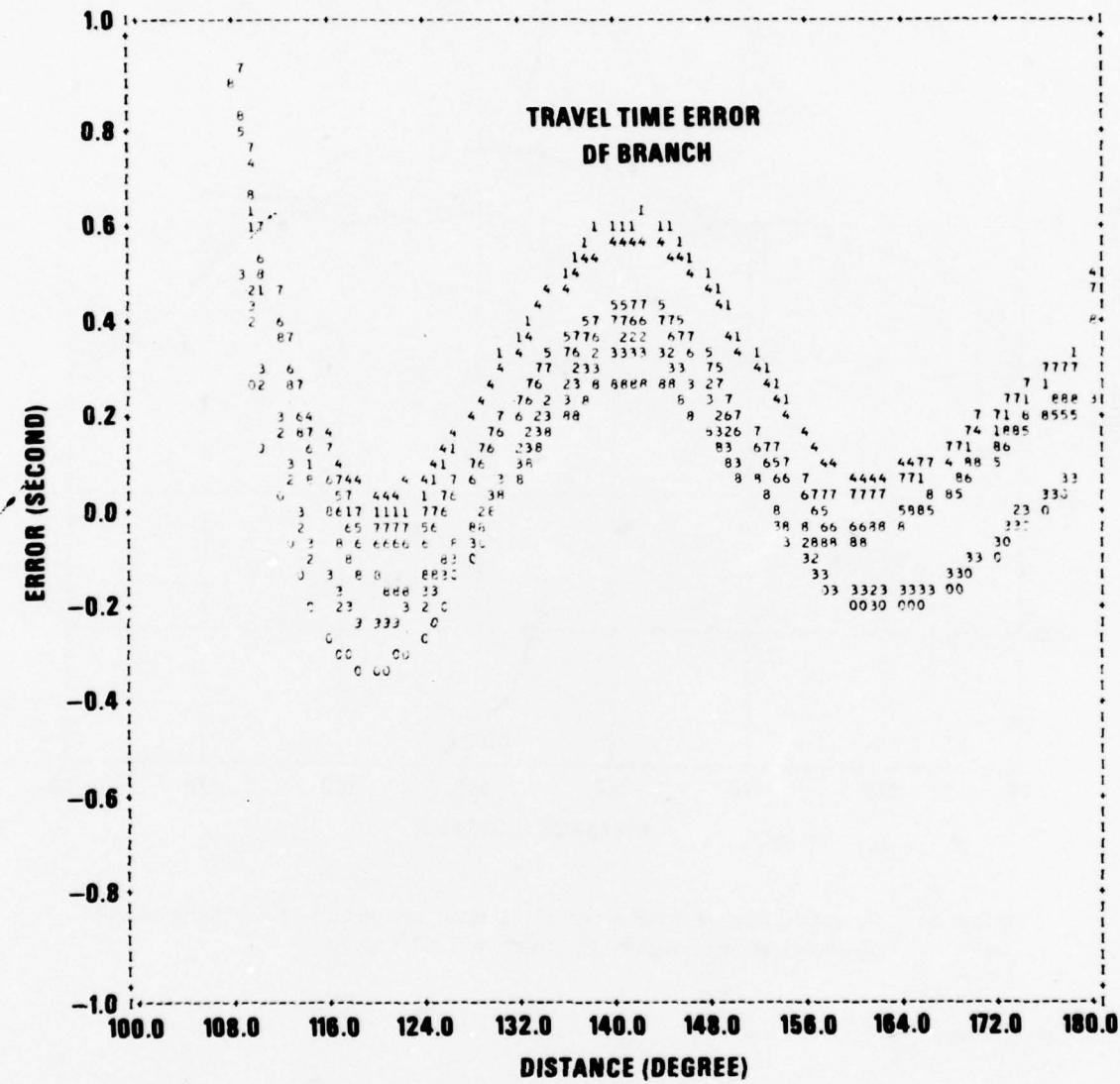


Figure 5. Travel time errors of PKP-DF branch computed with polynomial approximation. Numbers indicate depth of epicenter in hundreds of kilometers.

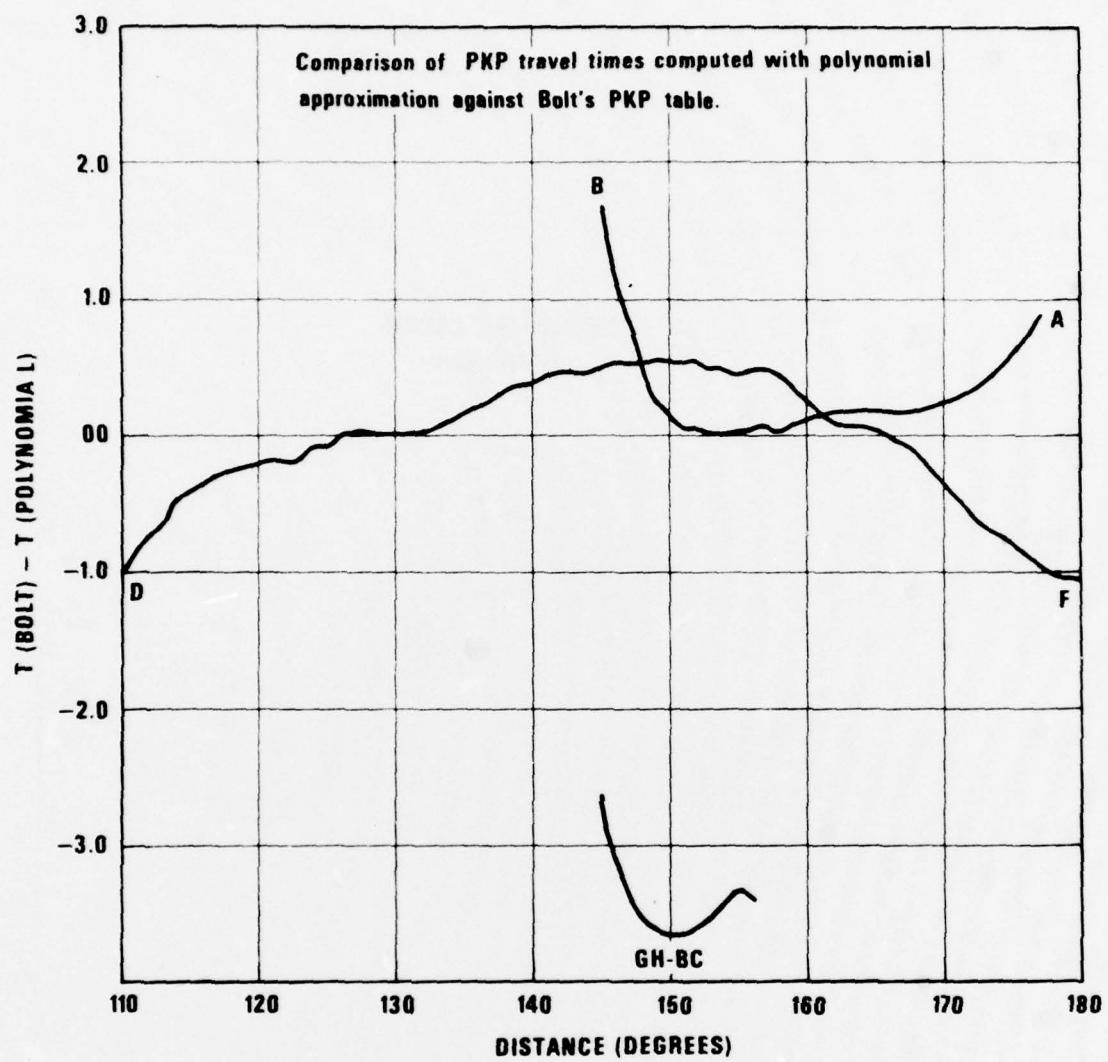


Figure 6. Comparison of PKP travel times computed with polynomial approximation against Bolt's PKP table.

B FACTORS FOR PKP

Perhaps because of the confusion in mixed branch arrivals, PKP amplitude-distance relationships are not well defined. Shurbet (1967) made a comprehensive study of PKP amplitudes for the range of 110° - 180° . For each event, he used the amplitude of the event at a station near 125° to normalize all observations. He encountered difficulty with multiple arrivals in the caustic zones; so, in general, his results give only the largest amplitude observed at a given distance. Engdahl (1968) reported some 70 PKP amplitudes with a comparable number of PKKP and related amplitudes from two earthquakes.

Sweetser and Blandford (1973) defined the PKP amplitude distance relationship by using $\log(A/T)$ of events reported by ISC bulletins, the VELA observatories, and LRSN station bulletins. Only shallow events were used in this study. Although this work is perhaps the most comprehensive study of PKP amplitudes to date, even this table is available only as a single value at each given distance in the caustic zone, and applies only to shallow events.

Computing theoretical PKP amplitudes depends not only upon the earth's velocity model but also upon the earth's anelastic attenuation (the Q model); Q models of the earth vary widely among researchers. To circumvent the uncertainties that Q models caused, we adjusted Q so that the calculated surface focus B factors fit Sweetser's and Blandford's results (1973).

Julian's ray tracing program, TVT6, allows us to compute the correct amplitudes of each ray taking account of divergence and anelastic absorption. We made a minor modification to this program to convert the amplitudes into B factors. The procedure can be described in two steps: 1) Veith's and Clawson's Q (1973) mantle model was used and B factors were computed for teleseismic P waves. Q values of each layer were then adjusted to obtain good

Shurbet, D. H., 1967, The earthquake P-phases which penetrate the earth's core; Bull. Seism. Soc. Am., 57, 875-890.

Sweetser, E. I., and R. R. Blandford, 1973, Seismic distance-amplitude relations for short period P, Pdiff, PP, and compressional core phases for $\Delta > 90^\circ$; Teledyne Geotech, SDAC-TR-73-9, Alexandria, VA.

Veith, K. F., and G. E. Clawson, 1972, Magnitudes from short-period P-wave data; Bull. Seism. Soc. Am., 62, 435-452.

agreement between the theoretical B factors and Veith's and Clawson's observations; 2) we adopted the Q model at 1 Hz of Gilbert et al., (cited in Doornbos 1974, p. 409), and calculated B factors for PKP waves. Adjustments in the Q of the core were then made to match the resulting B factors for PKP-DF with those of Sweetser and Blandford, with the exception of the mixed branch amplitudes in the range of 145° to 158° .

Figure 7 compares the starting Q models of the mantle and the core, as well as the final result, with our adjustments. To match the rising B factors beyond 80° , values of Q are sharply lower at the lower mantle area. They are also somewhat lower in the inner core in order to match the result of Sweetser's and Blandford's B values.

Figures 8a and 8b show travel times and distance-amplitude relationships, respectively, for all PKP branches. Note that the amplitude of CD branch is larger than the DF branch's in the 110° - 151° range.

Theoretical B factors for nine depths for all PKP branches are shown in Figures 9 through 12; Table V gives the B factors for each branch for nine depths. For comparison, the practical B factors of Sweetser and Blandford are plotted in Figure 12.

Doornbos, D. J., 1974, The Anelasticity of the Inner Core; Geophys. J. R. Astr. Soc., 38, 397-415.

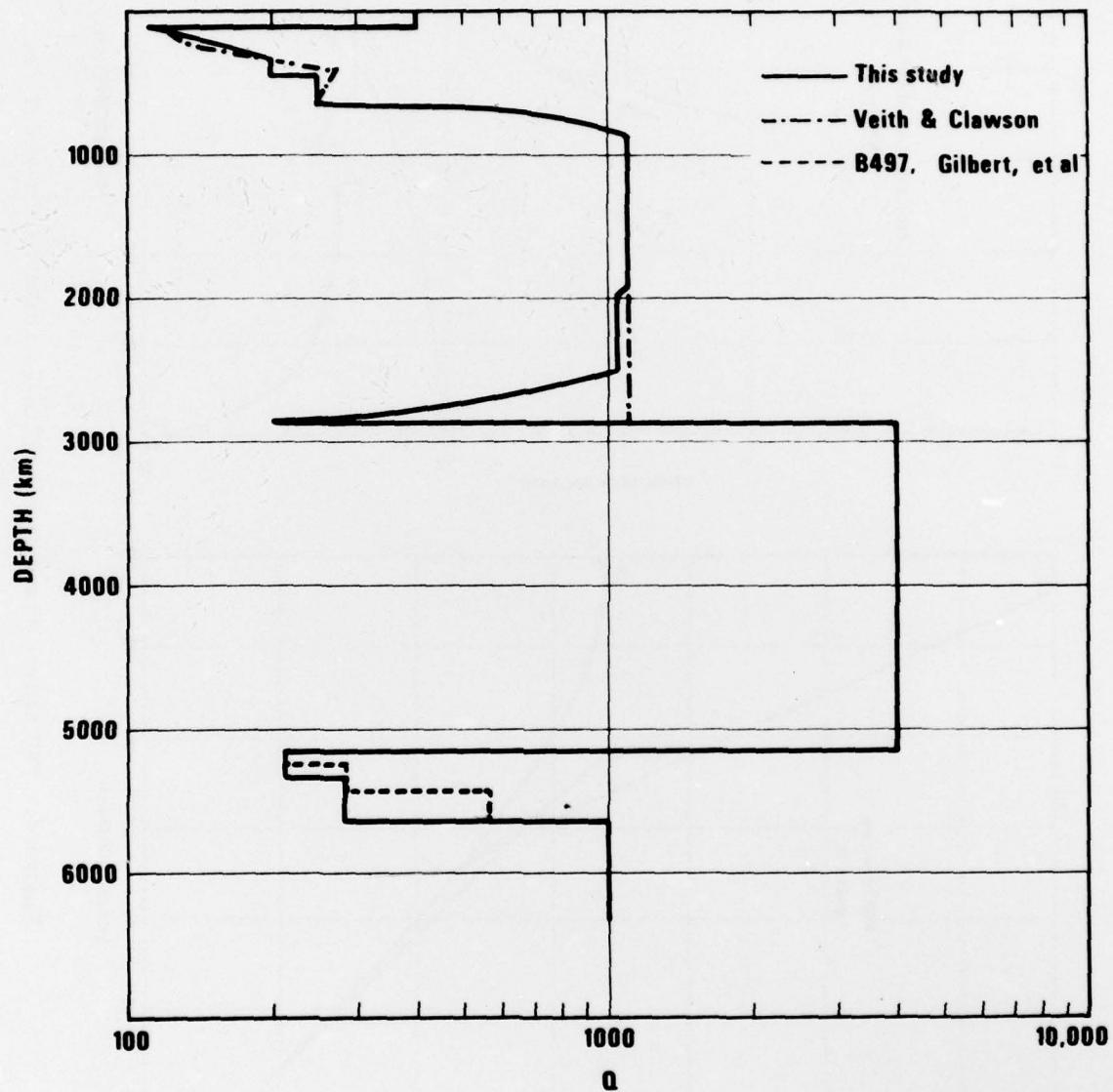


Figure 7. The Q model of the earth used in PKP amplitude computation as compared with Veith and Clawson's Mantle Q model and Doornbos' core Q model.

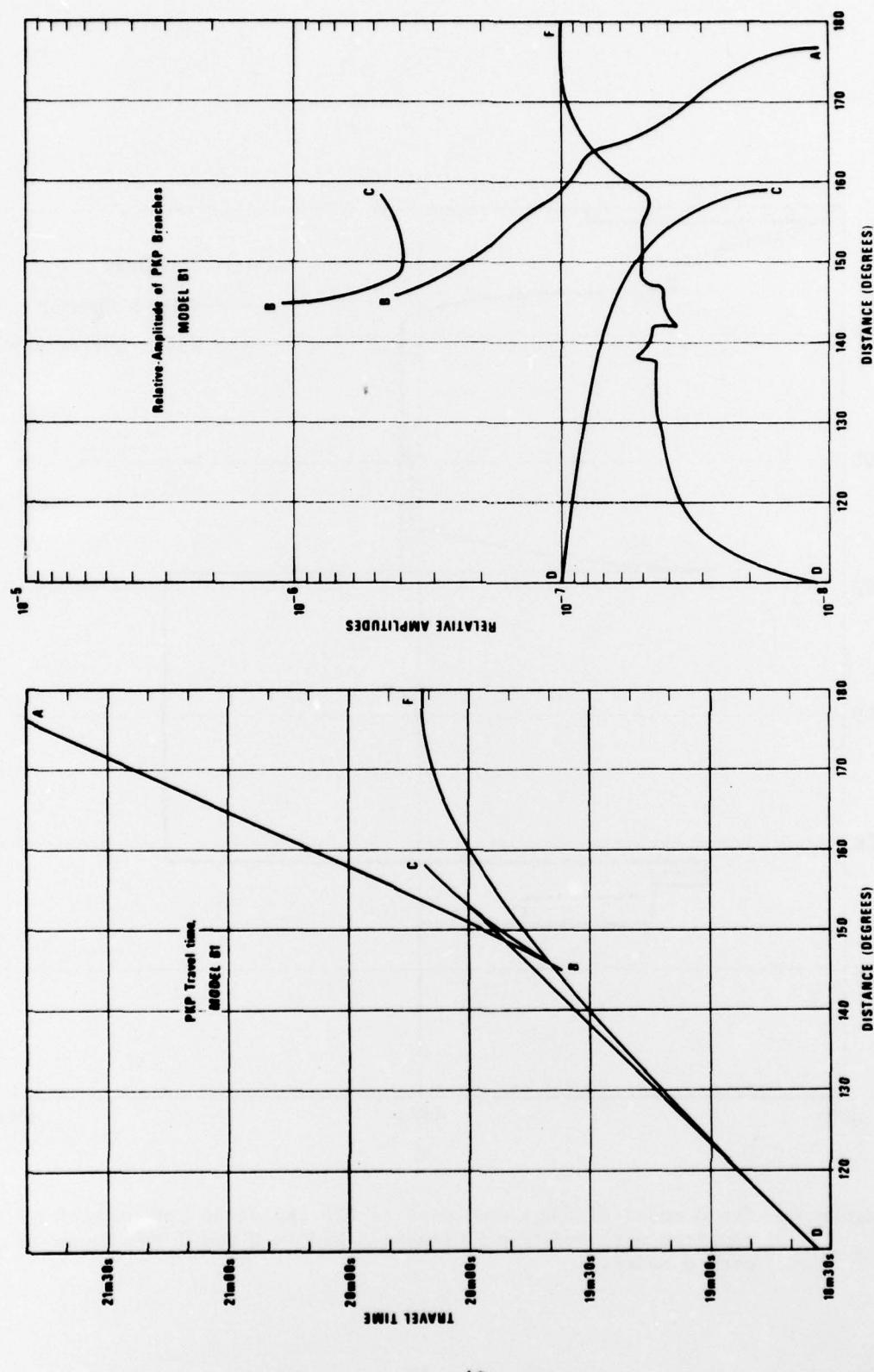


Figure 8. PKP travel times and amplitudes computed for model B1.

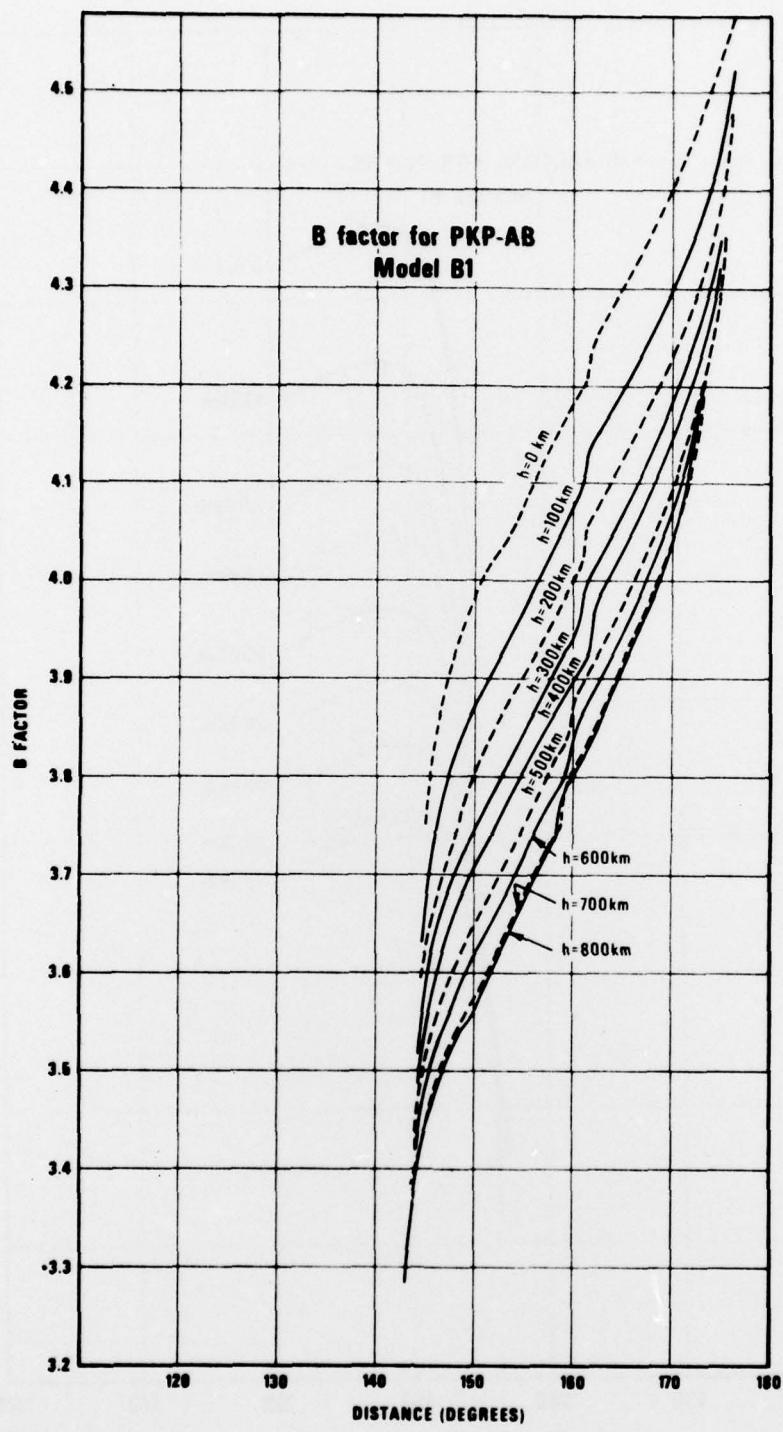


Figure 9. B factors for PKP-AB branch.

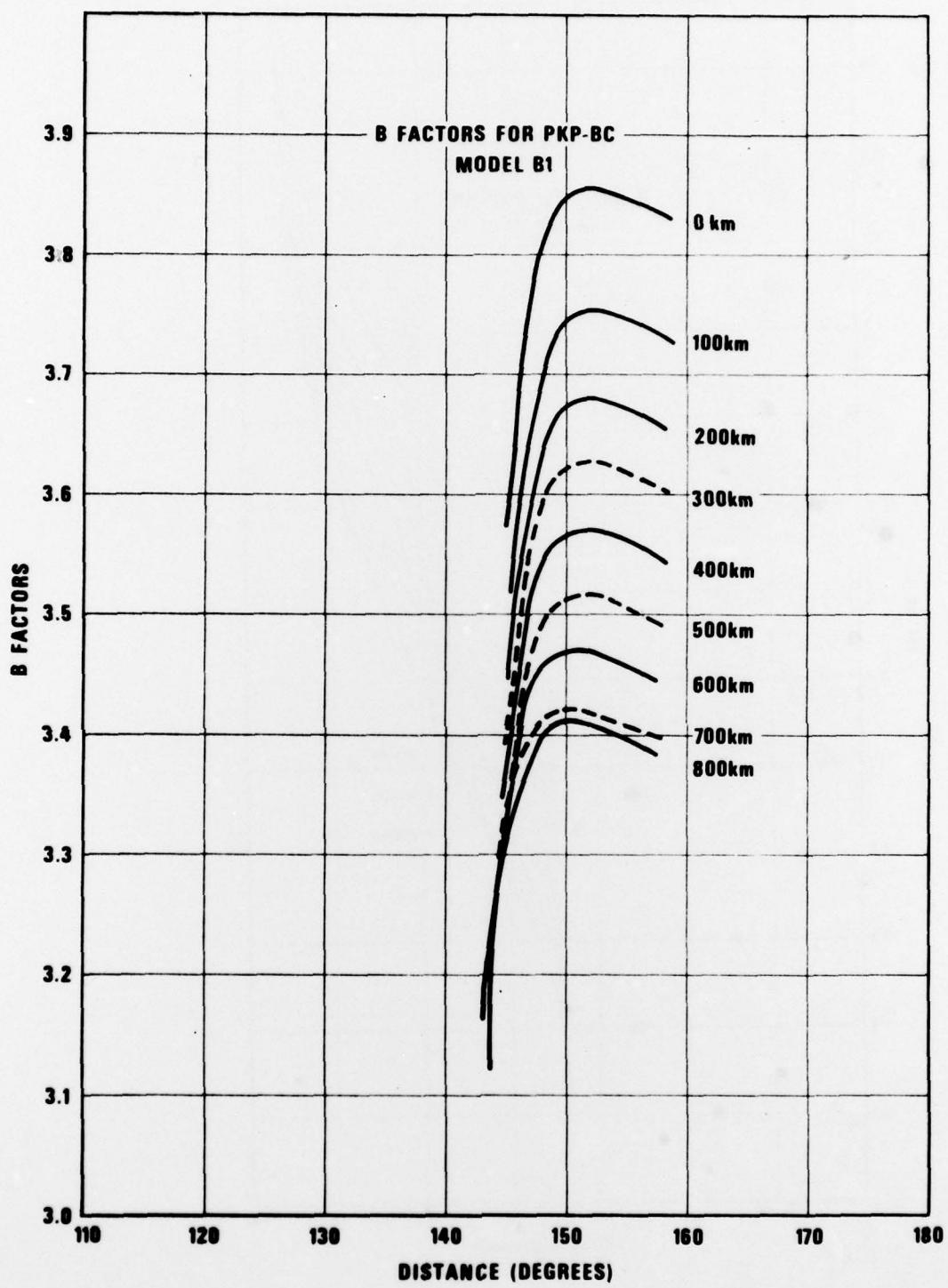


Figure 10. B factors for PKP-BC branch.

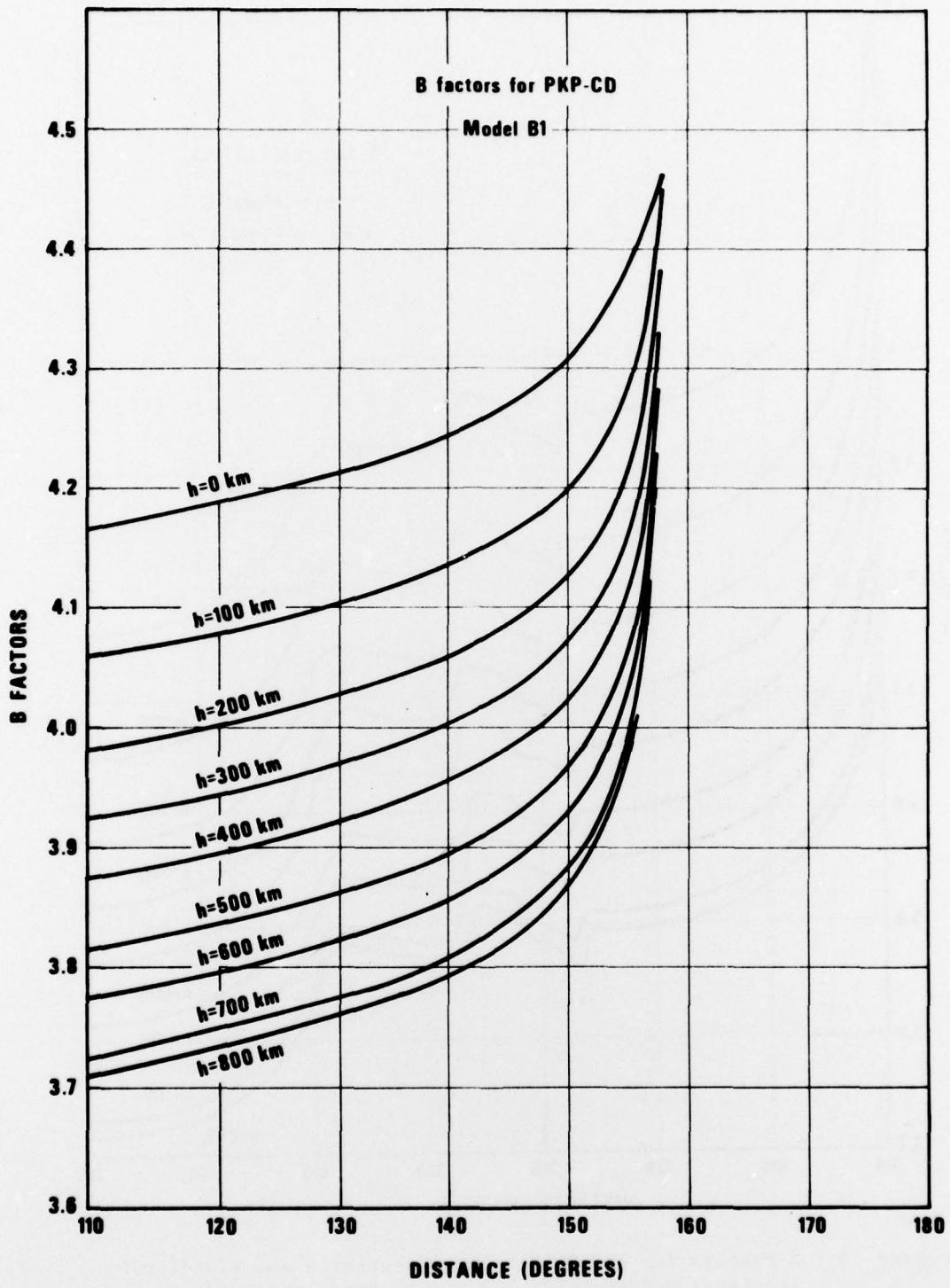


Figure 11. B factors for PKP-CD branch.

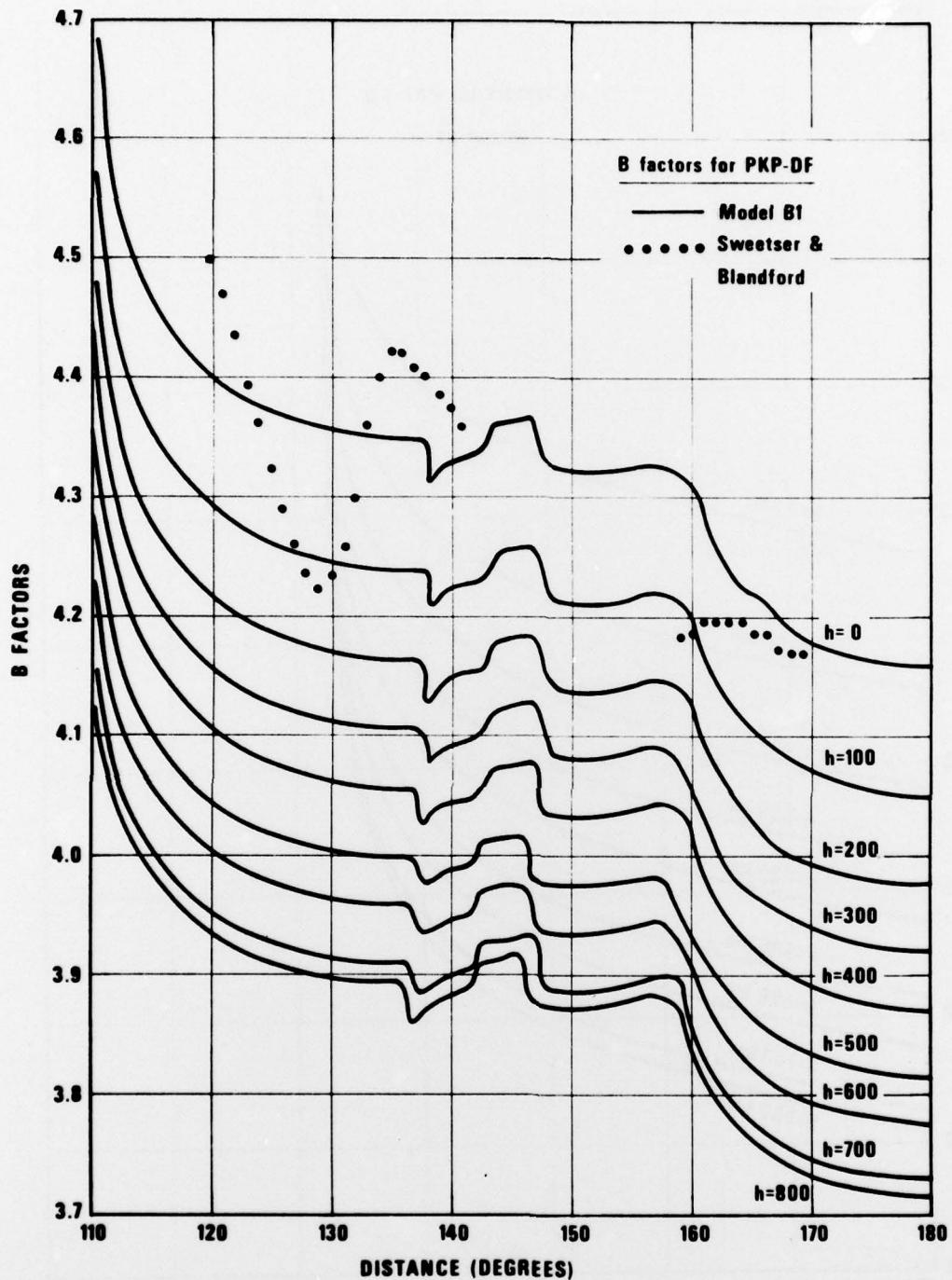


Figure 12. B factors for PKP-DF branch. Sweetser's and Blandford's practical B-factor for PKP are plotted in dotted line for comparison.

TABLE V

		B Factors for PKP-AB							
		100	200	300	400	500	600	700	800
Δ	0	3.60	3.54	3.49	3.45	3.43	3.40	3.38	3.35
145	3.70	3.68	3.61	3.55	3.51	3.48	3.45	3.42	3.40
146	3.77	3.71	3.65	3.59	3.55	3.50	3.47	3.44	3.43
147	3.81	3.75	3.68	3.63	3.58	3.53	3.50	3.46	3.45
148	3.85	3.77	3.70	3.65	3.61	3.56	3.52	3.47	3.46
149	3.88	3.80	3.72	3.67	3.63	3.58	3.53	3.50	3.47
150	3.90	3.82	3.74	3.69	3.64	3.59	3.55	3.51	3.50
151	3.93	3.83	3.76	3.70	3.65	3.60	3.57	3.53	3.52
152	3.94	3.84	3.77	3.72	3.67	3.62	3.58	3.54	3.53
153	3.95	3.86	3.79	3.73	3.69	3.63	3.60	3.56	3.55
154	3.97	3.88	3.81	3.75	3.71	3.65	3.62	3.62	3.57
155	3.99	3.88	3.82	3.82	3.77	3.73	3.67	3.63	3.59
156	4.00	3.90	3.90	3.82	3.77	3.73	3.67	3.63	3.58
157	4.02	3.91	3.84	3.79	3.74	3.69	3.65	3.61	3.60
158	4.04	3.92	3.86	3.80	3.76	3.70	3.67	3.62	3.61
159	4.05	3.94	3.87	3.82	3.77	3.71	3.68	3.65	3.65
160	4.06	3.96	3.88	3.83	3.79	3.73	3.70	3.67	3.67
161	4.08	3.98	3.90	3.87	3.82	3.77	3.73	3.69	3.68
162	4.11	4.01	3.94	3.89	3.84	3.78	3.75	3.70	3.70
163	4.13	4.02	3.95	3.90	3.85	3.80	3.76	3.72	3.72
164	4.15	4.04	3.97	3.91	3.87	3.81	3.78	3.74	3.73
165	4.16	4.05	3.98	3.93	3.88	3.83	3.80	3.76	3.75
166	4.17	4.07	4.00	3.94	3.90	3.84	3.81	3.77	3.76
167	4.19	4.08	4.01	3.96	3.91	3.86	3.83	3.79	3.78
168	4.21	4.10	4.03	3.97	3.93	3.88	3.85	3.81	3.80
169	4.22	4.11	4.04	3.99	3.95	3.90	3.87	3.83	3.84
170	4.24	4.13	4.06	4.00	3.97	3.92	3.89	3.85	3.83
171	4.26	4.15	4.08	4.02	3.99	3.94	3.91	3.88	3.87
172	4.27	4.17	4.10	4.05	4.01	3.96	3.94	3.91	3.90
173	4.29	4.19	4.12	4.07	4.04	3.99	3.98	3.95	3.95
174	4.31	4.21	4.14	4.10	4.08	4.04	4.03	4.03	4.03
175	4.33	4.25	4.19	4.15	5.13	4.10			
176	4.36	4.25	4.22						
178	4.45								

TABLE V (Continued)

B Factors for PKP-BC

Δ	0	100	200	300	400	500	600	700	800
143								3.17	3.13
144							3.22	3.29	3.26
145	3.62	3.56	3.50	3.45	3.40	3.36	3.31	3.29	3.29
146	3.71	3.64	3.56	3.49	3.46	3.39	3.36	3.34	3.33
147	3.75	3.66	3.58	3.53	3.48	3.42	3.37	3.35	3.33
148	3.77	3.67	3.60	3.54	3.49	3.44	3.39	3.36	3.34
149	3.78	3.68	3.61	3.55	3.50	3.45	3.40	3.36	3.34
150	3.79	3.68	3.61	3.56	3.50	3.45	3.41	3.37	3.35
151	3.80	3.69	3.62	3.57	3.51	3.45	3.41	3.37	3.35
152	3.80	3.69	3.62	3.57	3.51	3.46	3.42	3.37	3.35
153	3.81	3.70	3.62	3.57	3.52	3.46	3.42	3.38	3.36
154	3.81	3.70	3.63	3.57	3.52	3.46	3.42	3.38	3.36
155	3.81	3.70	3.63	3.57	3.52	3.46	3.42	3.38	3.36
156	3.81	3.70	3.36	3.58	3.52	3.46	3.42	3.38	3.36
157	3.82	3.70	3.63	3.58	3.52	3.47	3.43	3.38	3.36

TABLE V (Continued)

		B Factors for PKP-CD							
		100	200	300	400	500	600	700	800
Δ	0	4.13	4.02	3.94	3.89	4.84	3.78	3.74	3.69
110	4.13	4.02	3.95	3.89	3.84	3.78	3.74	3.69	3.68
111	4.13	4.02	3.95	3.89	3.84	3.78	3.74	3.69	3.68
112	4.13	4.02	3.95	3.89	3.84	3.78	3.74	3.69	3.68
113	4.13	4.03	3.95	3.89	3.84	3.78	3.74	3.69	3.68
114	4.14	4.03	3.95	3.89	3.84	3.79	3.75	3.70	3.68
115	4.14	4.03	3.95	3.90	3.85	3.79	3.75	3.70	3.68
116	4.14	4.03	3.96	3.90	3.85	3.79	3.75	3.70	3.69
117	4.14	4.03	3.96	3.90	3.85	3.79	3.75	3.70	3.69
118	4.14	4.03	3.96	3.90	3.85	3.79	3.75	3.70	3.69
119	4.14	4.03	3.96	3.90	3.85	3.79	3.75	3.70	3.69
120	4.15	4.04	3.96	3.91	3.86	3.80	3.76	3.71	3.69
121	4.15	40.4	3.97	3.91	3.86	3.80	3.76	3.71	3.70
122	4.15	4.04	3.97	3.91	3.86	3.80	3.76	3.71	3.70
123	4.15	4.04	3.97	3.91	3.86	3.80	3.76	3.72	3.70
124	4.16	4.05	3.97	3.92	3.86	3.81	3.77	3.72	3.70
126	4.16	4.05	3.98	3.92	3.87	3.81	3.77	3.72	3.71
127	4.16	4.05	3.98	3.92	3.87	3.81	3.77	3.73	3.71
128	4.17	4.06	3.98	3.92	3.87	3.82	3.78	3.73	3.71
129	4.17	4.06	3.99	3.93	3.88	3.82	3.78	3.73	3.72
130	4.17	4.06	3.99	3.93	3.88	3.82	3.78	3.73	3.72
131	4.17	4.06	3.99	3.93	3.88	3.03	3.79	3.74	3.72
132	4.18	4.07	3.99	3.94	3.89	3.83	3.79	3.74	3.73
133	4.18	4.07	4.00	3.94	3.89	3.83	3.79	3.74	3.73
134	4.18	4.07	4.00	3.94	3.89	3.84	3.80	3.75	3.73
135	4.19	4.08	4.00	3.95	3.90	3.84	3.80	3.75	3.74
136	4.19	4.08	4.01	3.95	3.90	3.84	3.80	3.75	3.74
137	4.19	4.08	4.01	3.95	3.90	3.85	3.81	3.76	3.74
138	4.20	4.09	4.01	3.96	3.91	3.85	3.81	3.76	3.75
139	4.20	4.09	4.02	3.96	3.91	3.85	3.81	3.77	3.75
140	4.21	4.09	4.02	3.97	3.91	3.86	3.82	3.77	3.76
141	4.21	4.10	4.03	3.97	3.92	3.86	3.82	3.78	3.76
142	4.22	4.10	4.03	3.97	3.92	3.87	3.83	3.78	3.77
143	4.22	4.11	4.04	3.98	3.93	3.87	3.83	3.79	3.77
144	4.23	4.11	4.04	3.99	3.93	3.88	3.84	3.79	3.78

TABLE V (Continued)

		B Factors for PKP-CD							
Δ	0	100	200	300	400	500	600	700	800
145	4.23	4.12	4.05	3.99	3.94	3.88	3.85	3.80	3.79
146	4.24	4.13	4.05	4.00	3.95	3.89	3.85	3.81	3.79
147	4.25	4.13	4.06	4.00	3.96	3.90	3.86	3.81	3.80
148	4.25	4.14	4.07	4.01	3.97	3.91	3.87	3.82	3.81
149	4.26	4.15	4.08	4.02	3.98	3.92	3.88	3.83	3.82
150	4.27	4.16	4.09	4.03	3.98	3.93	3.89	3.85	3.83
151	4.28	4.17	4.10	4.04	4.00	3.94	3.90	3.86	3.85
152	4.29	4.18	4.12	4.06	4.01	3.96	3.92	3.88	3.86
153	4.31	4.20	4.13	4.07	4.03	3.97	3.94	3.89	3.88
154	4.33	4.21	4.15	4.09	4.05	4.00	3.96	4.02	3.90
155	4.34	4.23	4.18	4.11	4.08	4.02	3.99	4.05	4.04
156	4.37	4.26	4.21	4.17	4.11	4.07	4.04		
157	4.43	4.33	4.28	4.23	4.17	4.17	4.17		
158	4.52	4.42	4.45	4.29					

TABLE V (Continued)

		B Factors for PKP-DF							
Δ	0	100	200	300	400	500	600	700	800
111	4.46	4.44	4.36	4.29	4.24	4.17	4.13	4.06	4.03
112	4.45	4.39	4.30	4.24	4.18	4.12	4.08	4.02	3.99
113	4.43	4.34	4.27	4.20	4.14	4.09	4.04	3.99	3.96
114	4.42	4.31	4.24	4.17	4.12	4.06	4.02	3.96	3.94
115	4.40	4.29	4.22	4.16	4.10	4.04	4.00	3.94	3.92
116	4.36	4.25	4.18	4.12	4.07	4.00	3.96	3.91	3.89
118	4.34	4.24	4.16	4.10	4.06	3.99	3.95	3.90	3.88
119	4.33	4.23	4.15	4.09	4.04	3.98	3.93	3.88	3.87
120	4.32	4.21	4.14	4.08	4.03	3.97	3.92	3.87	3.86
121	4.30	4.20	4.13	4.07	4.01	3.96	3.91	3.86	3.85
122	4.29	4.19	4.12	4.06	4.00	3.95	3.90	3.85	3.84
123	4.28	4.18	4.11	4.05	3.99	3.94	3.89	3.84	3.83
124	4.27	4.17	4.10	4.04	3.98	3.93	3.88	3.83	3.82
125	4.26	4.16	4.09	4.03	3.98	4.02	3.88	3.83	3.81
126	4.25	4.15	4.08	4.02	3.97	3.91	3.87	3.82	3.80
127	4.24	4.14	4.07	4.01	3.96	3.90	3.86	3.81	3.79
128	4.24	4.14	4.07	4.01	3.95	3.89	3.86	3.80	3.79
129	4.23	4.13	4.06	4.00	3.95	3.89	3.85	3.80	3.78
130	4.22	4.13	4.05	3.99	3.94	3.88	3.84	3.79	3.77
131	4.22	4.12	4.04	3.99	3.94	3.88	3.83	3.78	3.77
132	4.21	4.11	4.04	3.98	3.93	3.87	3.83	3.78	3.76
133	4.21	4.11	4.03	3.97	3.92	3.86	3.82	3.77	3.76
134	4.20	4.10	4.02	3.97	3.92	3.85	3.81	3.77	3.75
135	4.19	4.10	4.02	3.96	3.91	3.85	3.81	3.76	3.75
136	4.19	4.09	4.01	3.96	3.91	3.84	3.80	3.76	3.74
137	4.18	4.09	4.01	3.95	3.90	3.84	3.80	3.75	3.74
138	4.18	4.08	4.00	3.95	3.90	3.83	3.79	3.75	3.73
139	4.17	4.07	4.00	3.94	3.89	3.83	3.79	3.74	3.73
140	4.17	4.07	3.99	3.94	3.89	3.83	3.79	3.74	3.72
141	4.17	4.07	3.99	3.93	3.88	3.82	3.78	3.73	3.72
142	4.16	4.06	3.99	3.93	3.88	3.82	3.78	3.73	3.71
143	4.16	4.06	3.98	3.92	3.87	3.81	3.77	3.72	3.70
144	4.15	4.05	3.97	3.91	3.86	3.80	3.76	3.71	3.70
145	4.14	4.04	3.97	3.91	3.86	3.80	3.76	3.70	3.69

TABLE V (Continued)

		B Factors for PKP-DF									
		0	100	200	300	400	500	600	700	800	
Δ	0	146	4.14	4.03	3.96	3.90	3.85	3.79	3.75	3.69	3.68
	147	4.13	4.02	3.95	3.89	3.84	3.78	3.74	3.69	3.68	3.68
	148	4.12	4.01	3.94	3.88	3.84	3.78	3.74	3.68	3.67	3.67
	149	4.11	4.00	3.93	3.87	3.83	3.77	3.73	3.67	3.66	3.66
	150	4.10	3.98	3.92	3.86	3.82	3.76	3.72	3.66	3.64	3.64
	151	4.09	3.97	3.91	3.85	3.81	3.75	3.70	3.65	3.63	3.63
	152	4.08	3.96	3.90	3.84	3.79	3.74	3.69	3.64	3.62	3.62
	153	4.07	3.96	3.89	3.83	3.78	3.72	3.68	3.63	3.62	3.62
	154	4.06	3.95	3.88	3.82	3.78	3.71	3.68	3.62	3.61	3.61
	155	4.05	3.95	3.87	3.82	3.77	3.71	3.67	3.62	3.61	3.61
	156	4.04	3.94	3.87	3.81	3.76	3.70	3.66	3.61	3.60	3.60
	157	4.03	3.94	3.86	3.80	3.76	3.70	3.66	3.61	3.60	3.60
	158	4.03	3.93	3.86	3.80	3.75	3.69	3.65	3.61	3.59	3.59
	159	4.02	3.93	3.85	3.79	3.74	3.69	3.65	3.60	3.59	3.59
	160	4.02	3.92	3.85	3.79	3.74	3.68	3.64	3.60	3.58	3.58
	161	4.01	3.91	3.84	3.78	3.73	3.67	3.64	3.59	3.58	3.58
	162	4.01	3.91	3.84	3.78	3.73	3.67	3.64	3.59	3.57	3.57
	163	4.01	3.91	3.83	3.78	3.73	3.67	3.63	3.58	3.57	3.57
	164	4.00	3.91	3.83	3.78	3.72	3.66	3.63	3.58	3.57	3.57
	165	4.00	3.90	3.83	3.77	3.72	3.66	3.63	3.58	3.56	3.56
	166	4.00	3.90	3.82	3.77	3.72	3.66	3.62	3.58	3.56	3.56
	167	3.99	3.90	3.82	3.77	3.71	3.66	3.62	3.57	3.56	3.56
	168	3.99	3.89	3.82	3.76	3.71	3.66	3.62	3.57	3.56	3.56
	169	3.99	3.89	3.82	3.76	3.71	3.66	3.62	3.57	3.56	3.56
	170	3.99	3.89	3.82	3.76	3.71	3.65	3.62	3.57	3.56	3.56
	171	3.99	3.89	3.81	3.76	3.71	3.65	3.62	3.57	3.56	3.56
	172	3.98	3.89	3.81	3.76	3.71	3.65	3.61	3.57	3.56	3.56
	173	3.98	3.89	3.81	3.76	3.71	3.65	3.61	3.57	3.56	3.56
	174	3.98	3.88	3.81	3.75	3.71	3.65	3.61	3.57	3.55	3.55
	175	3.98	3.88	3.81	3.75	3.70	3.65	3.61	3.57	3.55	3.55
	176	3.98	3.88	3.81	3.75	3.70	3.65	3.61	3.59	3.55	3.55
	177	3.98	3.88	3.81	3.75	3.70	3.65	3.61	3.56	3.55	3.55
	178	3.98	3.88	3.81	3.75	3.70	3.65	3.61	3.56	3.55	3.55
	179	3.98	3.88	3.81	3.75	3.70	3.65	3.61	3.56	3.55	3.55
	180	3.98	3.88	3.81	3.75	3.70	3.65	3.61	3.56	3.55	3.55

CONCLUSIONS

In this report we presented a set of PKP travel times and B factors computed with the Jordan and Anderson model B1. While arguments for the adequacy of the adopted earth model(s) are not in the scope of this report, the presentation of various tables and curves is novel and convenient for direct user application. The effort can be repeated in the future when better velocity and Q models become available.

ACKNOWLEDGEMENTS

We thank Dr. R. R. Blandford for his helpful suggestions and critical review of this report.

REFERENCES

Bolt, B. A., 1968, Estimation of PKP Travel Times; Bull. Seism. Soc. Am., 58, 1305-1324.

Cleary, J. R., and Haddon, R. A. W., 1972, Seismic Wave Scattering Near the Core-Mantle Boundary: A New Interpretation of Precursors to PKP; Nature, 240, 549-551.

Doornbos, D. J., 1974, The Anelasticity of the Inner Core, Geophys. J.R. Astr. Soc., 38, 397-415.

Engdahl, E. R., 1968, Core Phases and the Earth's Core, Ph.D. Thesis, St. Louis, Univ.

Geotech (1968). Equations for Computing Phase Travel-Times, Appendix 3 to Technical Report No. 68-28, Garland, Texas.

Hai, N., 1963, Propagation des Ondes Longitudinales dans le Noyau Terrestre, Ann. Geophys., 19, 285-346.

Herrin, E., 1968, P-Wave Velocity Distribution in the Mantle; Bull. Seism. Soc. Am., 58, 1223-1225.

Jacobs, J. A., 1975, The Earth's Core, New York: Academic Press.

Jeffreys, H. and Bullen, K. E., 1958, Seismological Tables: British Association for the Advancement of Science Publications.

Jordan, T. H., and Anderson, D. L., 1974, Earth Structure from Free Oscillations and Travel Times, Geophys. J. R. Astr. Soc., 36, 411-459.

Qamar, A., 1973, Revised Velocities in the Earth's Core; Bull. Seism. Soc. Am., 63, 1073-1106.

Shurbet, D. H., 1967, The Earthquake P-Phases Which Penetrate the Earth's Core; Bull. Seism. Soc. Am., 57, 875-890.

Sweetser, E. I., and R. R. Blandford, 1973, Seismic Distance-Amplitude Relations for Short Period P, P_{diff}, PP, and Compressional Core Phases for $\Delta > 90^\circ$, Teledyne Geotech, SDAC-TR-73-9, Alexandria, VA. AD 755-638.

Travis, H. S., 1965, Interpolated Jeffreys and Bullen Seismological Tables, Geotech, TR-65-35, Garland, Texas.

Veith, K. F., and Clawson, G. E., 1972, Magnitudes from Short-Period P-Wave Data; Bull. Seism. Soc. Am., 62, 435-452.